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French Ironfounders' Productivity Report

The Report of the French Ironfounders' Productivity Team which has been made available to us, is of a "general" character, and it is obvious that a document of a more technical character will be printed for the benefit of the actual foundries. There is a radical difference between the grey-iron production of the two countries. In the States, 3,000 foundries, employing 300,000 workpeople and staff, manufacture 10,800,000 [French] tons of castings annually, that is, 3 tons per man per month. The conditions in France are that 750 foundries employing 54,000 workpeople—the staff being excluded—produce 900,000 tons annually—that is 1.4 tons per man per month. The Report re-states much that is generally known here, due no doubt to the existence of a common language. There is, however, one remark worth stressing, and that is that while the American rate of foundry production is twice that of the French, yet the buying capacity of the individual is four times as great. Whereas this two to one difference in the output per man is an average, a case is cited in which a company employing 150 workpeople casts 30 tons of castings per day. A similarly-placed concern in France would normally teem about 10 tons. On the other hand there are cases where American jobbing foundries showed a productivity decidedly lower than to be expected from a French concern.

The Americans get the productivity by paying attention to the location of the plant; by rationalising the movement of materials; by the provision of appropriate tools, and benches of the proper height. The team noted that for the handling and stocking of the raw materials alone, the Americans employed one fifth the number of men as the French. The benefits of mechanisation are cited in two instances. One referred to an expenditure of half a million dollars on new plant which doubled production with the same labour force. The second with a similar expenditure increased production by 20 per cent. and reduced the number of employees by 50 per cent.

We have made a translation of the conclusions reached and printed in the Report:—"Primarily, there are the multiplicity of factors which determine the productivity of an industry, and outstanding amongst these are the size of the market, its structure and the natural resources of the conditions where it exists; the psychological surroundings in which it operates, and so forth. For the French grey-iron foundries, it should be pointed out that the market is but one tenth of the size of that of the United States, whilst its raw materials are five times as costly. It is not surprising, under such conditions, that the methods of production in the United States have received a different treatment, and as a result it has been possible to register the difference by the ratio of 2 to 1. Also, it is evident that, at least under the present state of affairs, the French cannot exactly emulate the American methods, so closely associated with high production, and it is now necessary to envisage the adoption of those which can show immediate results. In this connection, there is the question of simplification of methods, the rational utilisation of working places, job breakdown, and so on, to the price of average materials—often on the high side. For the implementation of these matters, the team has brought back much data, which will be widely disseminated."

The Report finishes on a note which applies equally well in this country, and that is, until this new knowledge can be generally applied, the foundries should continue on the progressive lines characteristic of the post-war period. Obviously, the average foundry has not yet availed itself to the full of the indigenous beneficial notions. Attention to them will render shops more receptive to imported suggestions.

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Foundry Careers

At a meeting of the Walsall Foundry Joint Recruitment and Training Committee, held at the Walsall Employment Exchange last week, under the chairmanship of Mr. Gilbert Harvey, Mr. R. Forbes Baird, secretary of the West Midland Foundry Advisory Committee, described the work done at the National Foundry Craft Training Centre at West Bromwich, and illustrated the useful and comprehensive training that was given to craft apprentices during their periods of four weeks' intensive study, both practical and technical, at the centre. Mr. Forbes Baird said it was very interesting to note that trainees from iron foundries all over Britain were being sent to West Bromwich for this training. Over 100 trainees had received instruction at the centre, and courses were being booked by interested employees right up to September this year.

Mr. L. F. Cox, youth employment officer, reviewed recruitment of youths to the ironfoundry trade in the Walsall area, and described how much improved were conditions, illustrating his statements with comparisons of the opportunities offered to boys entering the foundry under the Foundry Training Scheme with the facilities of only a few years ago. Nevertheless, he felt that the Walsall Foundry Joint Recruitment and Training Committee might still consider improvements to the training scheme, and suggested that daytime release to technical college, the introduction of a craftsman's certificate on completion of training, and a more comprehensive scheme to follow the progress of all entrants to the ironfoundry trade in the area might well be incorporated as a part of the Walsall Foundry Apprenticeship Scheme.

Mr. E. Jewitt, principal of the Walsall Technical College, said he felt that the college could meet an obvious need by providing all young persons in the industry with opportunities for study to obtain the Arts and Guilds certificate, he would be willing to provide the necessary facilities for the instruction if the iron founders would allow their boys to attend the technical school during the daytime.

Dinner

Foundry Coke Merchants' Association

The first dinner since the inception of the Association eight years ago was held last Friday at the May Fair Hotel, London, W.1. Mr. Arnold Carr presided, and at the high table were:—Mr. W. Armstrong; Mr. H. M. Brand; Mr. A. Dudley Evans; Mr. V. C. Faulkner; Mr. J. Y. Feggetter; Mr. N. L. Goodchild; Mr. F. Greenwell; Mr. W. A. Hodson; Mr. Barrington Hooper, C.B.E.; Dr. J. E. Hurst, J.P.; Mr. N. P. Newman, J.P.; Mr. Leslie O'Conner; Mr. H. W. Secker; Mr. J. J. Selby; Mr. R. Sydney Smeeth, and Mr. J. F. Stanier. The function was organised by Mr. F. Arnold Wilson. Extracts from the speeches delivered will be printed in our next issue.

Luncheon

A Group of London Founders

To honour three prominent American metallurgists, Mr. Max Kuniansky, a past president of the American Foundrymen's Association, Mr. G. Vennerholm, of Detroit, and Mr. W. W. Levi, of Lynchburg, Virginia, a luncheon party was held last Saturday at the Café Royal, Mr. V. C. Faulkner presiding. Others present were:—Mr. W. Braidwood; Mr. V. Delport; Dr. A. B. Everest; Mr. M. Glenny; Mr. Barrington Hooper, C.B.E.; Dr. J. E. Hurst, J.P.; Mr. K. Marshall; Mr. A. McLeod; Mr. E. S. Renshaw, and Mr. F. Arnold Wilson.

Institute of Vitreous Enamellers

Winter Meeting

The programme for winter meeting of the Institute of Vitreous Enamellers to be held at the Charing Cross Hotel, London, on March 8, is as follows:—11.30 a.m., "Cobalt and Nickel in the Vitreous-enamelling Industry," by J. E. Hansen, B.S., F.Am.Cer.Soc. (past president, American Ceramic Society), presented by G. C. Priddey, Mond Nickel Company, Limited. This Paper deals with some of the important functions carried out by cobalt and nickel in improving and extending the applications of vitreous enamel. 1.00 p.m., Luncheon. 2.15 p.m., depart for visit to E.M.I. Factories, Limited, Hayes, Middlesex; of particular interest at this works is the infra-red drying plant in the vitreous-enamelling department. The return to London will be arranged in time for members of the Midland Section to catch a train connection to Birmingham.

Applications to participate should be made to Mr. W. Thomas, honorary secretary, 74, High Street, Rickmansworth, not later than February 20.

Spring Meeting

So that members can reserve the dates, preliminary advice is given of a Spring Meeting of the Institute to be held at Torquay from April 20 to 22. The programme includes a visit to the clay mines at Newton Abbot, a technical Paper on clays and suspensions and one on the vitreous enamelling of light alloys. It is also proposed to arrange another works visit.

A full programme will be circulated in due course, but members are advised to reserve hotel accommodation individually well in advance. The Corporation of Torquay have kindly placed meeting rooms and other facilities at the disposal of the Institute. The President and Council feel sure that this meeting will prove of extreme interest to those engaged in the vitreous enamelling industry, and it is hoped that there will be a record attendance.

Forthcoming Events

FEBRUARY 20.

Sheffield Society of Engineers and Metallurgists.

"The Automatic Control of Open-hearth Furnaces," by T. Land, M.A., F.Inst.P., at the Royal Victoria Station Hotel, Sheffield, at 6.15 p.m.

FEBRUARY 22.

Institute of British Foundrymen.

London Branch:—"The Future of the Foundry Industry," by F. W. Rowe, at the Waldorf Hotel, Aldwych, London, W.C.2, at 7.30 p.m.

Institution of Production Engineers.

South Wales and Monmouthshire Section:—"Precision Castings for General-engineering Purposes," by Dr. F. Hudson, F.I.M., at the South Wales Institute of Engineers, Park Place, Cardiff, at 6.45 p.m.

FEBRUARY 24.

Institution of Mechanical Engineers.

Discussion on "The Application of Gas-turbine Technique to Steam Power," by J. F. Field, B.Sc., at Storey's Gate, St. James's Park, London, S.W.1, at 5.30 p.m.

FEBRUARY 25.

Institute of British Foundrymen.

Wales and Monmouth Branch:—"Cupola Charge Materials," Report and Recommendations of Sub-committee T.S.27 of the Technical Council, presented by a member of the Committee at the Engineers' Institute, Cardiff, at 6 p.m.

Institution of Production Engineers.

Halifax Graduate Section:—"Noise and Vibration in Machinery," by W. A. Tuplin, D.Sc., M.I.Mech.E., at the White Swan Hotel, Halifax, at 2.30 p.m.

Steel Founding

By F. A. Martin, O.B.E.

The findings of the first British productivity team to visit the United States under the auspices of the Anglo-American Productivity Council—those of the British steel founders—are embodied in this forthright address delivered by the team leader to the London branch of the Institute of British Foundrymen. Mr. F. Arnold Wilson presided at the meeting. The address has been left in Mr. Martin's inimitable style so as to preserve as far as possible the dynamic emphasis with which the remarks were delivered and which so greatly added to their appreciation by his audience.

EVERYONE knows about the Anglo-American Council on Productivity—how it was set up in 1948, at the instigation of Sir Stafford Cripps, Chancellor of the Exchequer, and Mr. Paul Hoffman, Administrator of Economic Co-operation Administration, or as we think of it in this country, Marshall Aid. It was set up because its originators believed that greater production for export by the people of this country was an essential part of the task of getting out of the economic mess in which we found ourselves.

So much has been written in our newspapers, placarded on walls, hoardings and transport vehicles and dinned into our ears in various B.B.C. programmes, of the importance of productivity, that I need add nothing here, except to remind you that the long words and fancy phrases mean simply that if we do not produce, from the fruits of the earth and the minerals thereof, from the work of our hands and the sweat of our brains, enough increase to satisfy our needs, and of the right type to exchange for what must be bought from other countries, we shall starve. That is simple enough as a spur to endeavour, if only we can realise the fearsome truth of it.

Granted, then, that higher production is required of us, there are, in theory, three ways to attain it: by putting more people to productive work; by working longer hours, up to the limit of increased output and by making their efforts more effective. Although it is not strictly within the subject of this talk, I want to say that in my opinion the time is more than ripe for a reversion to industry. By that I mean a turning back into productive work of the thousands upon thousands of fit and healthy people who spend their lives collecting, docketing, and filing information which does nothing towards increasing the wealth of the community, industrially, culturally or morally. True, they might be fairly useless in industry to begin with, but anyone can be trained to be of some use.

As to working extra hours, that is a subject we might leave. In such a gathering as this, probably a majority would welcome a return to a 56-hour week, from the 60 hours and more which they habitually devote to foundry work and study. In any case, the criticism of the 44-hour week shows a regrettable tendency to come from persons who have never engaged in really heavy manual work.

The third alternative is to make the efforts of industrial workers more effective—in other words, to

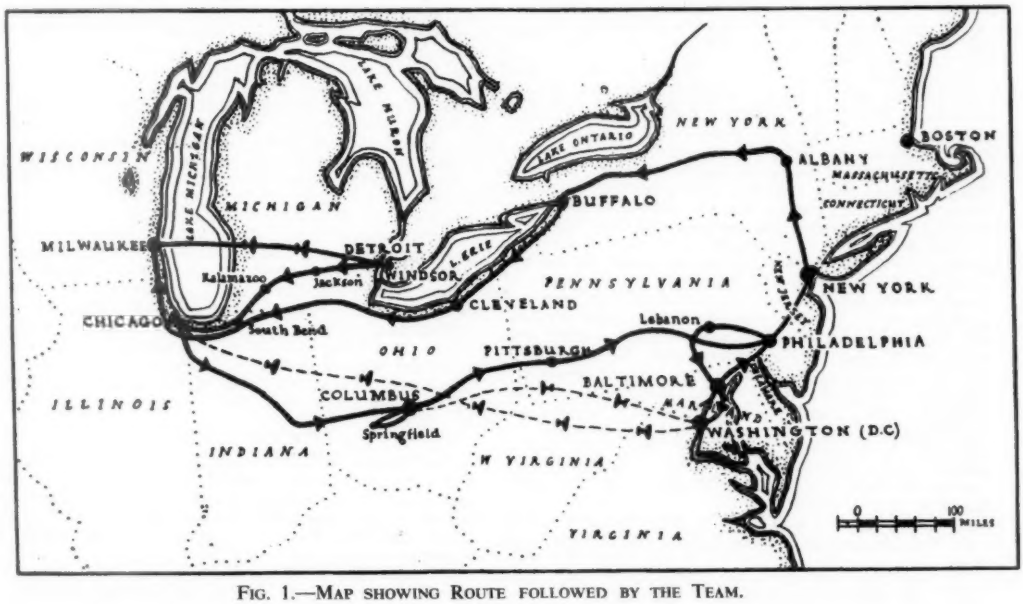


FIG. 1.—MAP SHOWING ROUTE FOLLOWED BY THE TEAM.

Steel Founding

raise their productivity. Of the earlier alternatives, the first would take too much time to be effective in the near future—yet remains important—and the second, that of longer hours, besides bearing heavily upon one section of the community, would not make enough difference.

The race towards economic collapse can be halted by higher productivity—if the increase be great enough. That is a reasonable deduction from the facts, and is a conclusion independent of the relative productivities of British and foreign industrial systems.

The Anglo-American Council on Productivity decided, among other measures, to arrange for teams representing each a particular section of British industry, to go to the U.S.A., where, as guests of that great nation, they would be enabled to study American methods and determine how productivity figures in American industries could be equalled or surpassed at home.

Now why was it assumed that from America there could be learned secrets which would put British industry on the right road? Was it genuine belief that the Americans had something we had not, or was it mere subservience to the people who had the dollars we wanted?

Early American Initiative

That is easily answered. Ninety-six years' experience constitutes an adequate reply to the sceptics. The team I had the privilege of leading was not the first productivity mission to the United States (though it was the first of its kind). In 1853, commissioners appointed by the British Government, disappointed in the postponed opening of the New York Exhibition, toured industrial districts, mainly in the New England region. Two of these men, Joseph Whitworth and George Wallis, presented particularly valuable reports. They were followed shortly after by John Anderson, Inspector of Machines in the Ordnance Department. He and his colleagues published a report which covered much the same ground as those of Whitworth and Wallis.

In D. L. Burn's words, "In all cases the writers emphasise 'the eager resort to machinery wherever it can be applied,' and the extent to which industries were organised for mass production in large factories, where in England outwork and handicraft persisted. Though they often criticised the quality of machine tools where there were English parallels, they had nothing but praise for the adoption in most branches of industry of the 'manufacturing principle,' the production in large numbers of standardised articles on a basis of repetition in factories characterised by ample workshop room and 'admirable system,' designed to assist the progress of materials through the various stages of production. The principle lent itself to the use of mechanical methods, particularly to the development of automatic 'special purpose' machines designed for a single operation, and dispensing largely with skilled labour. In devising machinery of this type, 'the Americans showed an amount of ingenuity, combined with undaunted energy, which we would do well to imitate if we meant to hold our present position in the great markets of the world.'"

The reports were published in 1854 and 1855, close on 100 years ago; so learning from America is nothing new.

Let us look now at some figures nearer our own time. In 1948 the Machinery and Allied Products Institute, of Chicago, published a report on a comparison of output per man of American Workers and British, in a number of industries.

TABLE I.—*American Man-hour Output. As a Percentage of British.*

Industry.	Percentage.
Blast-furnace products	447
Iron and steel products	495
Wire, cutlery, stoves	
Tools and implements	
Machinery	347
Cement	131
Coke	224
Automobiles	518
Radio sets	597

This surely is ample evidence that in some way the Americans had got far ahead of us in the technique of high production rates. Even 95 years after the Whitworth and Wallis report, it was worthwhile trying to learn from them. The important thing is that the Americans were not only willing that we should learn, but urged this policy with enthusiasm, and backed it with their own money.

The Steel-founders' Effort

In February 1949 it was decided that the trail should be blazed by the British steel founders. Urgency was the operative word, and the steel founders had an organisation, in the British Steel Founders' Association, ready to go into action on the shortest possible notice. There must also have been deeper influences at work. We in this room know that founding is one of the oldest arts.

It seems to me right and proper that so ancient a craft should now be seen willing to learn afresh from brother-craftsmen across the seas. Speaking as a steel founder, I find it peculiarly fitting that the noblest of our foundry metals should take pride of place in what has been described as "this adventure of friendship."

The Anglo-American Council on Productivity is representative of all interests in industry. So are the industrial teams. The steel-founding team consisted of sixteen men, five of whom were craftsmen working on the foundry floor, five being technicians—estimators, methods engineers, metallurgist—and five from the various grades of management, chargehand, foreman, foundry manager and director, with a secretary to do the dirty jobs which are always to be done.

Now what went we out for to see? The reports of 1853 and 1854, again to quote D. L. Burn, "were drawn up by men obviously qualified to judge the novelty and efficiency of the methods they discussed, though likely in the circumstances to describe the best practice rather than the average." The terms of reference of the First Productivity Team were: "to study factory administration, organisation, layout, methods and operating conditions," all within the pervading purpose of learning how to increase productivity. It is natural, then, that we should have reported upon the best we observed, only mentioning what was less satisfactory when it seemed that some admonitory lesson could be learned.

Productivity Defined

Our mission being to study productivity, we had to find some satisfactory definition of what we sought, and a means of measuring and comparing productivities in the two industries. In the report issued by the Team, the definition of the term is in the following words:

"Productivity is the ratio of production of wealth (goods, services and human satisfaction) to human

TABLE II.—*Comparisons of Productivity in Certain U.K. and U.S. Steel Foundries Expressed as Tons per Man-year and Man-hours per Ton.*

U.K. foundries.	Annual output gross tons.	Employees (Total).	Tons per employee	Hours per ton	Employees (shop level).	Tons per employee (shop level).	Hours per ton (shop level).
A	16,700	1,350	12.32	179	1,124	14.75	149
F	8,950	720*	12.43	177	666*	13.44	164
C	830	151	5.50	400	138	6.01	366
E	6,250	591	10.58	208	559	11.18	197
H	3,500	383	9.14	241	—†	—	—
B	3,500	334	10.48	210	288	12.15	181
G	7,540	581	12.82	172	516	14.61	151
	47,270	4,110	11.47	192	3,291	13.27	166

An estimate of the number of patternmakers working on repairs has been made. The number working on new patterns has been omitted from the above statistics.

* Number of employees is understated owing to the parent body carrying out clerical work, servicing, etc.

† Owing to insufficient detail it is impossible to determine the number of employees at shop level.

U.S.A. foundries.							
1	3,260	355	9.18	218	311	10.48	191
9	56,646	1,725	32.84	61	1,395	40.61	49†
10	7,442	415	17.93	112	321	23.18	86
3	6,071	288	21.08	95	249	24.38	82
8	11,160	651	17.143	117	506	22.055	91
4	12,500	518	24.131	83	460	27.173	74
11	4,200	319	13.17	152	250	16.80	119

Figures are based upon 44 hours per week per man for U.K. foundries and 40 hours per week per man U.S.A. foundries.

† Figures supplied by Foundry No. 9 were given as 48 hours per ton. This indicated that the assumption of 40 hours per week per man is correct.

effort expendable." That definition involves a concession to the limits of popular imagination. It might read, more concisely, and with equal effect: "productivity is the ratio of human satisfaction generated to human effort expendable."

The term "human effort expendable" calls for some evaluation, and demands acceptance of a quantitative measure expressible as *one man power*. This concept is capable of furnishing food for hours of fireside disputation, but I believe it to be admissible when comparing people so much alike as the Americans and ourselves. If one man power means the same thing in each country, it becomes a simple matter to adopt the even more simple unit of one man-hour as one term of the ratio of productivity.

The other term, which came to be accepted by the Team, may cause murmurings among foundrymen. We accepted as a measure of the production of wealth, the weight of good, finished black castings produced.

Foundrymen know that a ton of firebars is not comparable, in the wealth it represents, with a ton of diesel-engine cylinders; nor is a ton of steel coupling boxes of simple design to be compared with a ton of high-pressure turbine casings or pump parts. So simple a measure cannot be used for comparing the productivity of one company with that of another engaged upon quite different work, but if the comparisons are made over the whole of an industry such as steel founding, in the two countries, some reliance can be placed upon the results obtained.

In America it has been the practice of steel founders to take out this productivity ratio in the inverse form of man-hours per ton. Practically every steel founder makes returns to the Steel Founders' Society of America, whose technical director, Mr. C. W. Briggs, gave us global figures for castings produced by the two principal melting methods:—

55 per cent. of the total production of steel castings in U.S.A. is from open-hearth furnaces at 90 man-hours per ton.

42 per cent. of the total production of steel castings in U.S.A. is from electric arc furnaces at 110 man-hours per ton.

Table II, taken from the Report, shows some of the figures obtained from foundries visited by the Team. These vary considerably, but seem to confirm the figures given by Mr. Briggs. The table shows also some figures calculated as nearly as possible upon the same basis as the American practice, for a number of British steel foundries representing in total output nearly 25 per cent. of the whole of the industry in Britain. The ratio obtained in our case is 166 man-hours per ton. On this is founded the statement made in the Report and freely quoted in the Press, that productivity in U.S. steel foundries is between 50 and 90 per cent. higher than in Britain. If you will refer to Table I you may be inclined to think the British steel foundries show up not so badly in comparison with other industries cited. But do not dwell too long upon that thought. We cannot afford complacency. What is abundantly clear is that we must improve the productivity of the British steel foundries by 100 per cent. and then invite the Americans to come and learn from us!

Itinerary and Reception

We went out to try and find out how to do it. How did we go about the job? The job could only be done in one sort of place—on the foundry floors, and Fig. 1 shows the route followed by the Team. In all these places, we visited steel foundries, some 20 in all, and threw in a few iron foundries and mass-production works for luck. During the visits the Team broke up into groups, sometimes mixed groups including in each managers, technicians and craftsmen, but eventually getting down to brass tacks with our opposite numbers, moulder with moulder, methods man with methods man, and cost accountant with his American equivalent.

As to the reception we got, need I say any more than that we were foundrymen with foundrymen. You need no reminder that being a foundryman, and especially a steel foundryman, is one of the few completely satisfying jobs in this imperfect world, and that

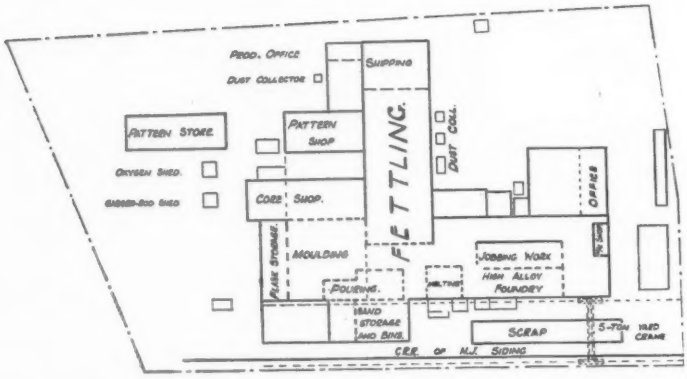


FIG. 2.—LAYOUT PLAN OF A U.S. STEEL FOUNDRY MAKING MEDIUM AND LIGHT STEEL CASTINGS.

the freemasonry of the moulder's trowel yields place to no other. "Come right in!" said the American founders. "Don't bother to wipe your feet on the mat. We, too, have sand between our toes."

Going out as a productivity team, we were prepared, if necessary, to find that the Americans had developed techniques of steel founding entirely unknown to us. We found instead that there was hardly a technique of steel founding used in America that was not known to us who constituted the Team—and we did not fancy we possessed full knowledge of British methods.

What we did find was a technique of productivity. Superimposed upon all the discussions of methods of melting, of managing labour, of mounting patterns and fettling green castings, we found a consciousness of the importance of high productivity. The reasons for its importance varied from one man to another. Naturally enough, the president of the company would think in terms of American national economy and his company's balance sheet; the plant manager had an eye to meeting his budget and earning a useful bonus on his salary, and the man on the floor wanted to earn enough to pay for that new refrigerator or washing machine his wife had bought, or he was anxious to prove to his immediate supervisor that he was good enough to be upgraded to a better job. All, too, were striving to maintain their own employment in face of competition from other foundries, other candidates for their jobs, and other means of producing engineering structures.

In such a soil, suggestions for improvements in productivity sprout readily, and their successful adoption is made to benefit the workers in the job. It is most important to note that improvements in productivity are regarded as opportunities to give benefit to employees of all grades who participate in the operations of producing at the higher rates. This principle is so much a part of the American industrial system that, in the steel foundries at least, it was never found to be in question. This points to one of our most serious shortcomings in Britain. There is insufficient faith in the operation of this principle; without that faith productivity-consciousness is hard to come by.

The principle does not only include payment of wages. Wages are worthless without goods on which to spend them, and their incentive value is sadly lessened by penal taxation. Doubtless the American grumbles about his taxes—that is one of the essential freedoms of democracy—but he has a good deal less to complain about than the British craftsman, who finds the extra earnings he hoped to get by overtime cut by a 45 per cent. tax.

It is necessary for me now to turn sharply off this path, lest we entangle our feet in the thorns and briars of politics. Instead, let us turn to the comforting assurance of a platitude which is at the same time axiomatic. Human effort is the source of all wealth. That being so, and the increase of wealth, which is human satisfaction, being our avowed aim, we ought surely to conserve human effort by every means known or discoverable, so as to apply effectively to our aim this strictly rationed commodity. Effective use of human effort involves skill.

It is inherent in my understanding of the word *skill* that skill represents ability above the standard of non-skill to produce wealth, and as a corollary, that skill which fails to meet this requirement is misapplied, or not worth calling skill. From this emerges the watchword of productivity, "Use your skilled men to the

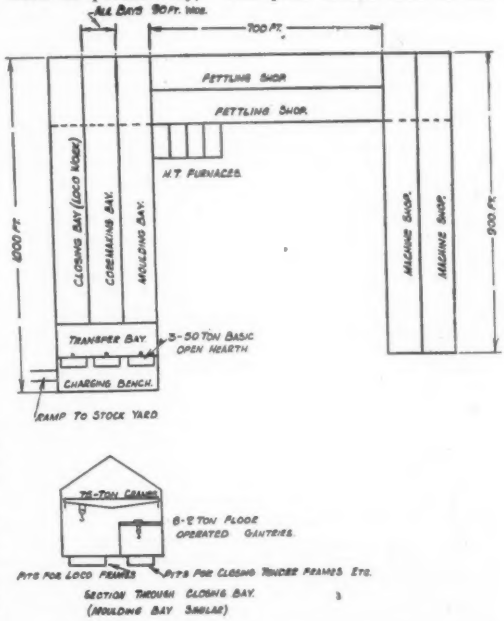


FIG. 3.—LAYOUT OF U.S. STEEL FOUNDRY MAKING HEAVY STEEL CASTINGS.

best possible advantage." Watch them at work; see whether their efforts are being dissipated in unnecessary movements or tasks which might as well be done by men with less skill. Most important of all, see that no man does by manual labour what could be done with less human effort by means of a machine. Remember, too, that the average unit *one-man power* is a mean of widely dispersed values. It is more important to economise the highly skilled man's time than that of the lower skilled.

Every man employed must, eventually, be regarded as a repository of some skill. Even the simplest action of the foundry floor sweeper is better done by a man than by dogs or mice. All man-power is valuable and must be saved.

Saving of man-power may be effected directly, by organising work in such a way as to avoid idle time. This is constantly under study in American steel-foundries, to a far greater extent than is common over here. The other method, to which I have already referred, is by the use of machines, not simply to reduce the number of men required to do a job—a rather negative approach—but to reduce the fatigue to which a man is subject so that by less concentrated expenditure of effort, he can produce more.

I have been asked again and again whether American foundrymen work harder than our folk here, and I find it most difficult to give a simple answer. They seem to spend less time recovering their breath, they are certainly much more promptly at their places of work when the starting whistle goes, and stay at it, working, until stopping time; they get through more production and shift a higher tonnage per man, but they seldom reach the peak rates of effort output which our foundrymen sustain for short periods. And in one example within my knowledge, where foundrymen have first-rate equipment and produce castings of as repetitive a nature as in the American foundries, output rates better than anything seen over there have been maintained over a long period. Given equal conditions, including full effectiveness for incentive systems, British steel foundrymen can produce as well as the Americans. There are even reasons why we ought to be able to do better. Given the willing spirit, the flesh unaided cannot achieve high productivity. Mechanical equipment well laid out and in plentiful enough supply must also join in the work.

Layout

Layout of factory buildings is one of the dominant influences upon ease of working. In this country we have steel and iron foundries well laid out for efficient production. We also have others whose layout would provide headaches for each separate head of the many-headed hydra, that mythical animal which sprouted two heads for every one that was cut off. Figs. 2 and 3 show examples of factory layout of buildings in two American steel foundries.

Melting Practice

These will have to suffice for the question of building layouts. Within the foundries we have first to consider steelmaking and the equipment used by the Americans. Thus, 55 per cent. of all steel for castings in America is melted in open-hearth furnaces, 20 per cent. in acid and 35 per cent. in basic linings; 35 per cent. is melted in acid arc furnaces, 7 per cent. in basic arc and only 3 per cent. in converters. Most of the open-hearth steel is absorbed in what are called speciality castings, such as railway rolling stock castings, leaving the acid arc furnace dominant in the field of general steel castings. Comparison with arc-furnace practice is of major interest to British steel founders.

The characteristics of melting procedure practised by the Americans are shaped by their determination to melt the greatest possible amount of steel with the lowest expenditure of man-power. Of the manning of furnaces I propose only to say that I observed a group of three arc furnaces which were operated by one chief melter, two helpers and three scrap men—six in all, with part-time help from the crane. These furnaces were not top-charged, but were producing one heat per hour—rather slower than the average in the foundries we visited. The men were all kept busy, but were not overworked.

In this country, working basic furnaces, we think a three-hour cycle, tap-to-tap, pretty good going. What would you think of the American who complained—yes, complained—that his tap-to-tap time was too long at 80 minutes? He was taking steps to reduce it to 70 minutes, and I have since heard from a member of his staff in this country, that the reduction has been effected.

To some extent the fast cycle is made possible by acid slag melting. Good scrap is available, and refining under a second slag is eliminated. That alone will not account for the fast melting. Transformer ratings are much higher per ton furnace capacity than is common in Britain. My informant, who wanted to reduce his melting time to 70 minutes cycle, had a 6,000-lb. capacity furnace with a 2,000-kva. transformer. His intention was to replace that with a 3,000-kva. installation, that is, 1,000-kva. per short ton. Such a ratio would require 1,120-kva. per long ton. Our average practice, as shown in the recent survey, is slightly above 350-kva. per ton.

It is true that, as Mr. D. F. Campbell pointed out in a letter to the *Iron and Coal Trades Review*,* a furnace of really high kva. rating per ton (5,000) was installed in this country before anything so heavily powered was built in America. That only makes the comparison the worse. That we should have had the lead and let it go to America shows that there is something seriously wrong with our outlook on technical advances.

Oxygen Boil

Another time-saver in regular operation in American steel-foundry melting shops is the use of oxygen to speed the boil. After the charge is fully melted, oxygen is blown in under the surface. For about two minutes the arc furnace becomes a convertor, and the end-point of the blow is judged by the same means as in a convertor—by the drop of the carbon flame. The boil is over soon, and the temperature is raised without using current.

Top charging of arc furnaces is common in both countries, but not every American arc furnace has this advantage. Yet I have still to see an American furnace-hand shovelling the charge into the furnace. That would offend his sense of fitness. Chute loading is the answer, and is illustrated in Fig. 4.

Among the " tips and wrinkles " which we picked up was the method used, shown in Fig. 5, to protect graphite stopper ends so that the stopper-rod ends would not catch too much heat. (Fig. 17 of Report.) In the foundry where this was seen, open-hearth steel at 1,700 deg. C. is tapped into a 30-ton ladle to cast between 250 and 300 boxes of thin-section castings. The practice is to use graphite stoppers and fireclay nozzles, but there was constant trouble with stopper ends coming away, until the development of the skirt projection on the lowest of the stopper sleeves.

* Electric Power in Steelmaking Furnaces, *Iron and Coal Trades Review*, November 11, 1949.

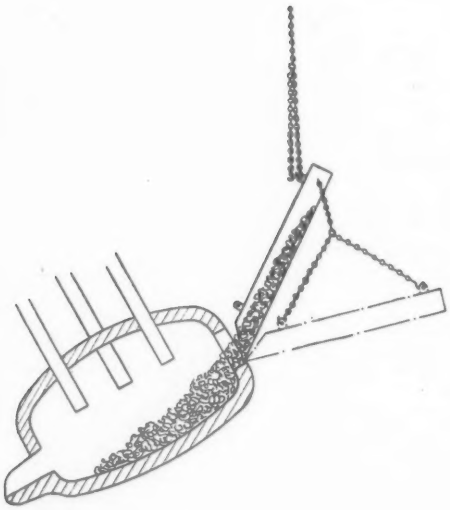


FIG. 4.—DIAGRAM SHOWING CHUTE CHARGING OF ARC FURNACE.

Sand Practice

Sand practice is a whole subject in itself, and has been dealt with fairly fully in the Report of the team. The outstanding points we observed were the almost universal adoption of synthetic sands, with bentonite bonding, and the use of finer grain sizes than are commonly employed in our steel foundries. A high degree of control is exercised over sands, with the end constantly in view of improving the strip. Core-sand mixes were found in great variety, with development of special mixes for particular purposes. Dyeing of sands is used to help the supervisor to control the work and avoid wrong use of special mixes.

Turning now to moulding equipment, let me draw your attention to a neat layout for moulding, casting and return, associated with a pair of pin-lift machines. This is shown in Fig. 6 and constitutes a satisfactory layout when moulding boxes are used, and the return box conveyor brings back empty boxes with the least trouble. American foundrymen, however, have paid increasing attention to the use of quick-acting snap-flasks, and claim that they obtain productivity rates about 25 per cent. higher by using them in place of boxes. We all know that when boxes are being standardised, the steps between successive sizes tend to be so wide as to lead to wastefulness in sand consumption, simply because each standard size must be represented by a large number of boxes. Both capital outlay and space can be saved by keeping the number of standard sizes to a minimum. With snap-flasks the capital outlay is of less consideration. One snap-flask, costing perhaps as much as ten ordinary boxes, can replace the whole stock, perhaps 200 or more, of that size, while the whole stock of snap-flasks requires less storage space than the previous stock for one standard size. So a full range of sizes can be constantly available, each job can be properly fitted to its appropriate box, and remilling of sand is kept to what is necessary.

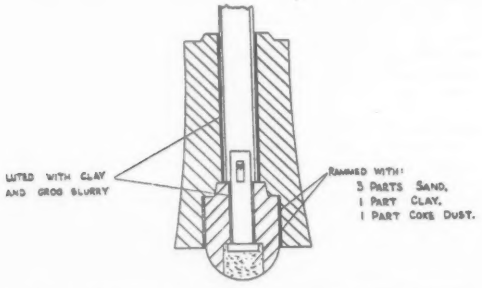


FIG. 5.—LADLE STOPPER ROD WITH SKIRT SLEEVE.

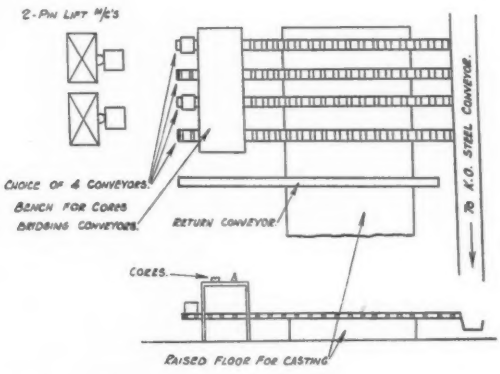


FIG. 6.—SECTIONAL LAYOUT OF TWO PIN-LIFT MOULDING MACHINES WITH CASTING AND RETURN CONVEYORS.

Add to this the constantly retained accuracy of pins and pinholes in boxes never subjected to heat, the certainty of a sand-to-sand joint, and the elimination of the box return from the shakeout, and the case for the snap-flask is seen in its full strength.

There are one or two drawbacks, however, which require to be overcome. The naked moulds are fragile. They cannot be pushed about on roller conveyors, and they need to have slip jackets put over them for the casting operation. The American practice observed is to have one row of moulds with slip jackets, and to transfer the jackets to the second row as the first row is cast. Some foundries successfully transported naked sand moulds on roller conveyors, using strong bottom boards. (The Americans suffer from no shortage of good timber). Others, however, use skids such as are shown in Fig. 7.

The use of skids allows more complete filling of the floor space with moulds. Provided there is over-

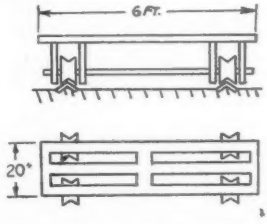


FIG. 7.—WHEEL CASTING SKID. THIS SKETCH SHOWS ROUGH CONSTRUCTION ONLY.

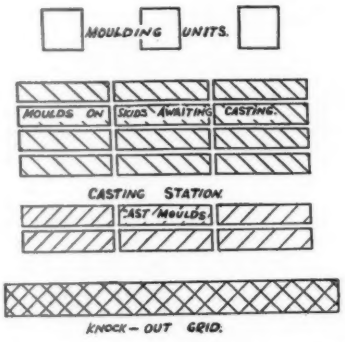


FIG. 8.—DIAGRAM SHOWING THE USE OF CASTING SKIDS ON THE FOUNDRY FLOOR.

head craneage, and the mould size warrants moving the ladle or shank along the line of moulds on a skid, the whole floor space may be filled solid with moulds on skids, saving only one working pathway. This is illustrated in Fig. 8.

Skids such as these are known in one or two of our steel foundries, but in America they are to be seen in the majority of foundries making small and medium work.

Another noticeable practice in the moulding shops was the wide use of Sandslingers on jobbing work. Once the facing sand is in position, all that is needed is to get backing sand filled in and rammed. The Sandslinger does this a great deal faster than can be done by hand—so the Americans use Sandslingers. These machines were seen in operation on all sizes of boxes, from 3 ft. by 18 in. up to 12 ft. square. In the latter case the Sandslinger used was a machine travelling on floor rails and carrying a 20-ton sand hopper. The arm had a reach of 30 ft. and the operator was seated at the end of the arm, just by the delivery head, whence he controlled the delivery of sand, up to a rate of one ton per minute, and the movement of the arm.

One more comment, before we leave the moulding shop. Why do moulders persist in strickling off the top surface of the cope? It is really wasted time, unless the cope is to be turned over on its back. We observed, on a pin-lift machine making copes in conjunction with a turnover machine for drags, that top ramming was confined to the areas around the downgate and the riser, and the top was left unstrickled. Moreover, the top-ramming was done automatically, while the mould was being jarred. Fig. 9 shows how this was done. The pegs for the downgate and riser were carried well above the top edge of the box, and metal rings placed on the sand and around the pegs. The jarring of the mould simultaneously caused local top

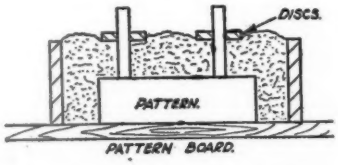


FIG. 9.—USE OF RAMMING DISCS ON PLAIN-BUMPER MOULDING MACHINE.

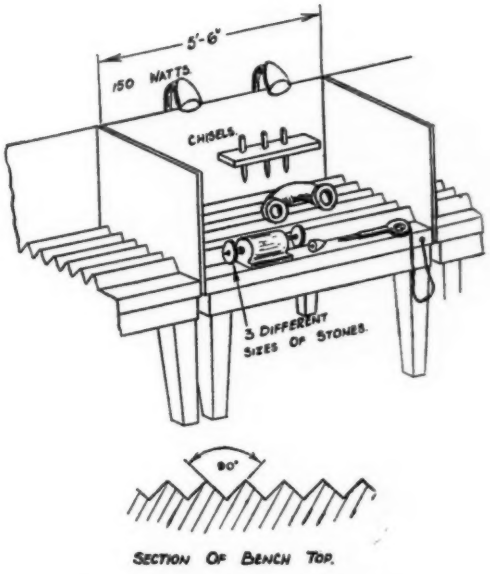


FIG. 10.—VIEW OF FETTLER'S BENCH.

ramming immediately beneath the rings, so that, as soon as jarring was complete, the cope could be stripped and lifted straight on to the drag.

Core Shop

In the core shops of American steel foundries there is not much to describe which is different from our best practice. Coreblowers are more widely used than in our steel foundries, but no more advanced than in British iron foundries. Perhaps the most striking observation is on mechanical handling devices. There is practically no hand lifting and carrying of cores. As

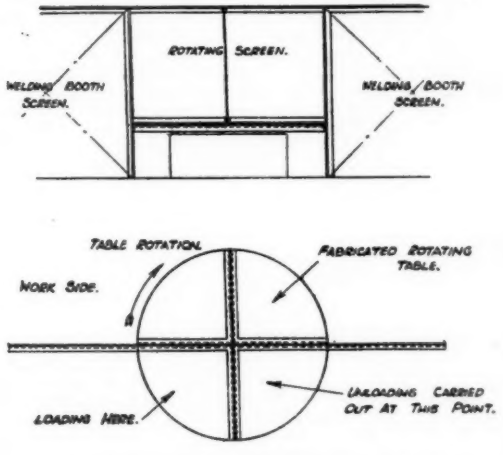


FIG 11—METHOD OF SEMI-CONTINUOUS WELDING.

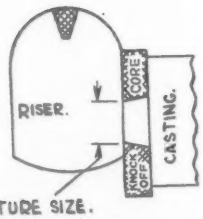


FIG. 12.—DIAGRAMMATIC VIEW OF KNOCK-OFF CORE.

cores are made, the coremaker places them on a rack or table at his side, or on a travelling band, and transport to the drying stove is done by some mechanical means, by fork truck, by conveyor or by wheeled or suspended rack. If it takes a man as long to walk from the core-bench to the stove, whether he is carrying one core or controlling a device which transports 100, then the proper course is obvious.

Fettling-shop Practice

The testing place of foundry practice is in the fettling shop. The Americans regard fettling as an undesirable operation, to be cut down to the lowest possible dimensions. They therefore choose those methods of moulding, of sand practice and pattern layout which will reduce the amount of fettling required. It is perhaps significant that they do not know the word "fettling." They refer to the cleaning operation, and the nearer they can get to a simple cleaning up, the better they are pleased. Flash, occurring on a repetition job, calls for a conference with the methods man. A burnt-on patch of sand means a call for the sand chemist. The first operation when a casting enters the fettling shop is shot-blasting, so that it is virtually free from sand for the whole of its passage through the shop. The last two operations are annealing and final shot-blasting.

Shot-blasting is thus a most important part of the cleaning operation, and has much attention in design of machinery. Perhaps the most impressive installation seen was an airless shot-blast of five tons loaded capacity. This machine was mechanically charged and discharged, and dealt with work at a staggeringly fast rate.

Many of the foundries are using round shot, malleablised. This cleans the surface well, but without cutting it as does angular grit. Instead, it appears to have a peening effect, and the surface of the blasted castings is left bright and pleasing to the eye. In the Milwaukee district the malleablised shot costs 40 per cent. more than the chilled, but has much more than 40 per cent. longer life.

Safety precautions in the fettling shop appeared good. Everyone in the shop, worker or casual passer-by, had to wear goggles or face-shield. Benches where small work was being fettled were divided into sections so as to screen each man from his neighbours. A diagram of one such bench is shown in Fig. 10.

American engineers have had the good sense to recognise that, in a cast structure, a repair by welding, which is also a cast structure, can be at least as sound as the weld which joins two wrought structures, as in a weldment.

Inspection

Non-destructive inspection of castings is employed by every foundry we visited, and faults are cut right out, preferably by oxy-acetylene gouge, and welded up. Welders are required to reach high standards of proficiency, and since they are skilled men, their time is not wasted fetching and carrying their work. It is usual to find welding booths fitted with screened tables, as shown in Fig. 11.

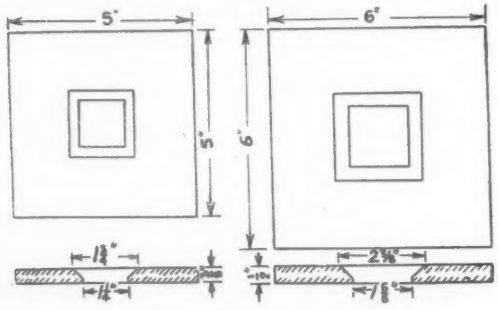


FIG. 13.—EXAMPLES OF SQUARE-APERTURE WASHBURN CORES.

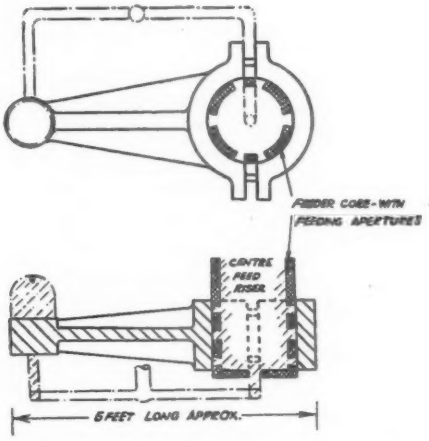


FIG. 14.—INTERNAL RISER FEEDING A BOSS.

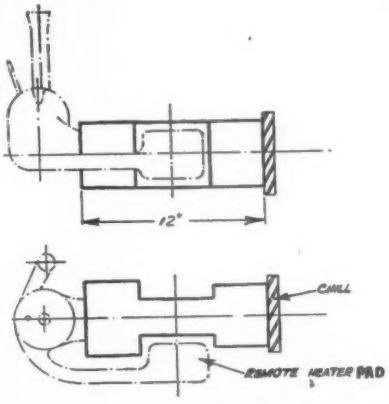


FIG. 15.—USE OF REMOTE HEATER PAD.

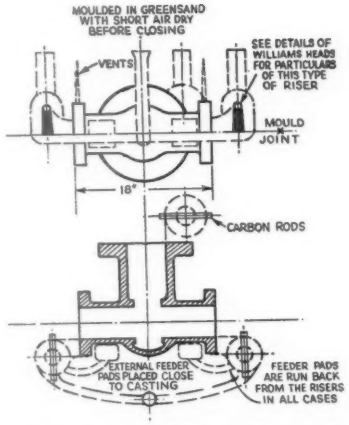

MOULDED IN GREENSAND WITH SHORT AIR DRY BEFORE CLOSING
SEE DETAILS OF WILLIAMS HEADS FOR PARTICULARS OF THIS TYPE OF RISER
VENTS
MOULD JOINT
18"
CARBON RODS
EXTERNAL FEEDER PADS PLACED CLOSE TO CASTING
FEEDER PADS ARE RUN BACK FROM THE RISERS IN ALL CASES

FIG. 16.—USE OF REMOTE HEATER PADS APPLIED TO PRODUCTION OF VALVE BODIES.

Directional Solidification

To deal adequately with the work of the methods departments of American steel foundries would take too much time for a single address. I propose to pass quickly over this aspect of our visit by illustrating a limited number of applications of methods designed to secure directional solidification in steel castings, at the same time choosing examples which illustrate other achievements.

First comes the Washburn core (Fig. 12), which consists, as you know, of a thin cake core separating the head from the casting, and having a narrow neck through which feeding takes place. This is used widely, both in the form of the necked down riser, and in conjunction with the whirlgate, Williams or heel riser head.

The aperture in the core is normally circular, but in some cases a square hole is preferred. For both, the Steel Founders' Society of America has published figures giving the correct dimensions for use in varying circumstances. These recommendations are reliable, and the American foundrymen use the Washburn core with complete confidence. A detailed view of the square-aperture core is given in Fig. 13.

The principle of the Washburn core is that the thin core is heated practically to the temperature of the surrounding steel, so that the neck remains open practically as long as though it were a full aperture, without any cake core. The advantage of its use is that the head can be removed by a blow from a hammer, thus saving the expensive time and materials required for burning off.

Two most interesting applications of this principle were seen in use. The first consists of an internal riser in a boss, as is shown in Fig. 14. The advantage of such a riser for avoiding laborious shaping of the outer contour by oxy-acetylene torch is clear. The next application is that known as the remote heater pad. Fig. 15 illustrates this in diagrammatic form. An application of this principle to feeding a valve seat is illustrated in Fig. 16.

A quite different method of obtaining directional cooling is known to us under the name of "Complete Reversal." I had personally seen examples of partial reversal, but no case of complete reversal had come under my notice until we saw the method illustrated in Fig. 17.

Fig. 18 shows the use of alternating heads and chills to secure soundness at the ends of arms on a six-arm gear blank. There is nothing very original about this, but it gives me the opportunity to mention the extensive use made of chills in American steelfoundry practice. Not only do the Americans use heavy chills such as we know, and internal chills as well, but they have adopted widely the practice of using quite thin sheet-steel chills to solidify fillets. These chills are provided with spikes to secure them in the sand, and are thin enough to be bent by hand to the required radius, so as to lie along the fillet. Because they are thin, they frequently fuse on to the casting and, if so, they may be allowed to stay there, quite unashamed.

One more aspect of directional solidification: for years and years we have added feeding powders of one sort or another to our open feeding heads. Some of them have been highly carbonaceous, and have reduced the freezing point of the steel in the heads, with little respect for the composition. Others have acted as heat insulators. Many attempts have been made to use exothermic reactions to keep the head liquid longer than the section it had to feed. All fell short of what was needed. The simple answer is now known, and has found expression in regular foundry practice in America. The heat cannot get down to where it is needed, because the exothermic reactions have been taking place at the top of the feeder and not near its base.

It is not a very difficult matter to formulate an oxidation/reduction reaction mixture of the thermit type so as to yield an end product of the same composition as the steel being used for casting. If that is done, the reaction can be used for supplying liquid steel, not simply as a source of heat, but as part of the feed. Moreover, the heat of the reaction, even if slowed down by restrainers, is sufficient to supply steel hot enough to remelt the steel in the immediate vicinity and ensure continuity of the cooling structure.

Granted these premises, it is easy, after someone else has told us about it, to see that the proper technique is to use short heads, with only enough steel in them to satisfy the early feed demand of the casting. Then, when the steel in the head has sunk almost to the level of the casting, top up with the exothermic material, enough to fill the head to the height necessary to care for the final feed demand. The head is then full of steel a good deal hotter than what was originally poured from the ladle, and the likelihood of directional cooling greatly increased. Fig. 19 shows the application of this method to a grooved pulley casting.

Conclusion

I have failed of my object in speaking to you, if it is not clear that we found in the American steel foundries a lively interest in increasing productivity by every technical and managerial means, and a readiness to accept new machines, new techniques, new ideas.

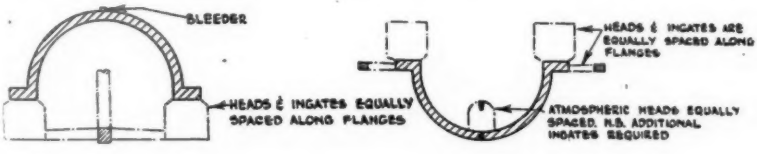

BLEEDER
HEADS & INGATES EQUALLY SPACED ALONG FLANGES
HEADS & INGATES ARE EQUALLY SPACED ALONG FLANGES
ATMOSPHERIC HEADS EQUALLY SPACED. N.B. ADDITIONAL INGATES REQUIRED

FIG. 17.—(*a*) TURNOVER METHOD, AND (*b*) IMPROVED METHOD, OF CASTING TURBINE CASING.

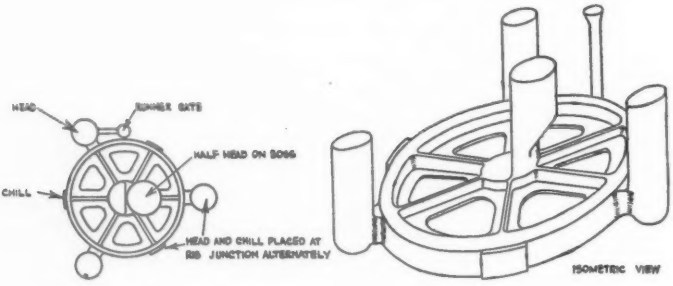


FIG. 18.—USE OF SIDE HEADS, CHILLS AND GRAVITY HEAD ON A SIX-ARMED GEAR BLANK.

American foundrymen are full of a courageous experimentalism. That spirit is to be seen at all levels. There is no break in the chain from vice-president of the company down through supervisory grades, to the man on the machine. Similarly, on the technical side, the work of the researchers is taken right to the foundry floor, in simple language and clear recommendations.

That is not happening in this country. If it were, our productivity would be much higher. Why is it not happening? I try to look at these problems with simplicity. The man at the top is responsible for all the people under his control; therefore he is to blame for what is wrong.

Most foundrymen have other persons who are answerable to them. If what is wrong is to be found among them, it is their responsibility. It is for them to take steps to put it right. Most of us are also answerable to senior officers of our organisations. If there are faults in the levels above us, may it not be because we are failing the men who rely upon us? It is for us to put that right.

We have responsibilities both ways, and we waste our time trying to blame anyone else but ourselves. Each of us has a definite job to do in getting Britain out of her present mess. If what I have told you helps a single one of you to help her, that will add to the reward I have received already in your patient attention to what I have said.

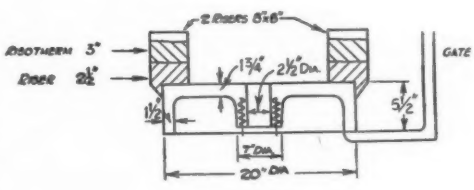


FIG. 19.—USE OF EXOTHMERIC HEADS ON A PULLEY.

Radiographic Service for Steel-foundry Personnel

Experience has shown that there is a potential risk in steel founding of men contracting pneumoconiosis, commonly referred to as silicosis. This risk is, generally speaking, restricted to men engaged on dressing steel castings in the finishing operations by means of pneumatic chisels. The incidence of pneumoconiosis has been the subject of considerable research during the last few years, and the British Steel Founders' Association has had a special committee—the Health in Steel Foundries Committee—engaged on study of the problem for several years. The Chief Inspector of Factories' "Dust in Steel Foundries Committee," on which the B.S.F.A. is represented and with whom it co-operates closely, has also been working on the problems involved.

It is reasonably well established that the main cause of the disease is the constant inhalation of fine, freshly broken particles of silica of less size than 5 μ. Measures for suppression or removal of such particles, and for the substitution of non-siliceous materials wherever practicable, have made progress during the last few years.

As a precautionary measure, however, the British Steel Founders' Association has recently arranged with Portable X-rays, Limited, to provide a travelling X-ray van solely for the services of its members. The van is equipped with the latest most powerful and sensitive X-ray equipment of the rotating-anode type, and capable of taking 17 by 11-in. radiographs with an exposure time of 0.2 sec. The van will make one or two tours each year of the various steel foundries in England, Scotland, and Wales, radiographing all personnel subject to silicosis risks in the foundries. The resulting radiographs will be examined by an eminent consulting radiologist, and the results communicated to the medical officer of the firm concerned. By this means it is hoped to detect the very earliest onset of pneumoconiosis so that men can be transferred to a dust-free occupation before the disease can take a hold, and the radiographs will form the basis for closer research into the causes and methods of prevention of pneumoconiosis.

The van started the first of its tours on January 26, its first assignment being at the works of K. & L. Steelfounders & Engineers, Limited, of Letchworth, where the first batch of men will be examined. This company was one of the pioneers of X-ray examination for steel-foundry personnel, and has had regular X-ray examinations of its men since 1941.

Paris Trade Fair

During the second week of the *Foire de Paris* (May 13 to 29) a Franco-British Day is to be held. British business men attending the Fair will that day be the guests of the organisers at a banquet at which a prominent French official will preside to welcome them. A representative of the Fair has already visited Birmingham, Manchester and other cities to invite business men to visit the Fair in groups. A special programme for visitors and their wives has been drawn up. All interested in visiting the Paris International Trade Fair and taking part in the Franco-British celebration should write, as early as possible, to the *Foire de Paris*, 23, rue Notre Dame des Victoires, Paris, 2e.

Correspondence

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

The Implications of Inspection

To the Editor of the FOUNDRY TRADE JOURNAL

SIR,—By a remarkable coincidence, I opened my February 9 copy of the JOURNAL this morning (page 137) within a few minutes of having laid aside the manuscript of a just-completed article entitled "That Specification: Master or Servant?" My manuscript begins thus:—

> "Although this article has been written primarily with a view to helping those who may be concerned with the manufacture, supply, testing, and applications of certain cold-rolled non-ferrous metals, it may be not without interest to the general reader, for, as its title indicates, it deals with a problem which exists in many branches of industrial metallurgy."

The theme of my Paper is almost exactly that of your own, in the third paragraph of your Editorial, namely, that there is a good deal of frustration and wasted effort in the foundry trade which could be avoided by the co-operation, *ab initio*, of manufacturer and purchaser, in respect of each individual job. It is pleasing to have from your pen so timely and spontaneous a confirmation of my own contentions. You suggest that the right specification for a job is one in which its provisions (*i.e.*, tests) are related and suited to the processing and ultimate use of the castings in the buyers' works. How right you are, but how rarely is this appreciated and acted upon and how frequently is the opposite procedure—that of making the job fit into an established *general* specification—adopted? It seems, from your remarks, that the latter habit of mind is as prevalent in the foundry trade as it is in the branch of the cold-rolled non-ferrous industry in which I am occupied. This is not to suggest that the conventional specifications, whether for castings or rolled metal, are not valuable; but there does appear a need to stress the other aspect of the matter. In my own manuscript I have attempted to crystallise into a definition something to which I have given the name "Specification Habit," and if my use of the word "specification" be taken (where applicable) to include "drawing," I think it (the definition) could be applied with very slight alleration, and with a good deal of truth, to the foundry trade. Anyhow, for what it is worth, here it is:—

> "The specification habit is an attitude of mind towards specifications. It is the practice of regarding the coupling of a named specification with a particular job (or order) as a sort of insurance (the specification being the 'policy') whereby the insured is indemnified against the supply of unsuitable material or goods. The craving for this insurance—this shifting of personal responsibility on to the specification itself, whereby it becomes the scapegoat for someone's lack of knowledge—is frequently accompanied by carelessness in the *choice* of the 'policy.' But, having made the choice, rightly or wrongly, the question of suitability fades right out of the picture. For, once the specification is chosen, it somehow or other (by the most extraordinary operation of wishful thinking) becomes divinely invested, as it were, with the *unquestioned* virtue of suitability and must accordingly be revered and complied with, to the very last letter of its provisions, be they never so inapplicable!"

Yours, etc.,

THOMAS B. CROW.

Victoria Rolling Mills,
Birmingham, 6.
February 10, 1950.

Risers which are Too Generous Cause Trouble

By "Tramp"

Risers fill numerous functions in foundry practice, one of which, in high-duty iron and steel work, is the provision of a reservoir of liquid metal to fill the rapidly-shrinking metal in the mould cavity and thus produce sound castings. This method of ensuring solidity, however, unless carefully controlled, tends to decrease the yield of castings from the metal handled, especially if the moulder is over-generous with his risers, and wasters may also accrue.

A particular case, known to the writer, of a defect in a casting of a lumpy nature, although it was provided with risers, is recalled in this connection. In this instance, the casting, a type of belt pulley, exhibited a drawn spot after machining, and it was considered that the casting had been made without adequate risers. As a number of similar castings were still going through the foundry, these were examined and showed ample riser capacity. Indeed, it was concluded eventually that these risers were the cause of the trouble, as the casting was only about 1 ft. 6 in. diam., and two heavy risers were situated diametrically opposite each other on the rim. The result was that the sand between these risers was considerably heated by the mass of liquid metal and created a "hot spot" below the junction of the riser with the casting, resulting in the draw complained of. Upon removing one of these risers from the mould set-up, the trouble was cured, as the casting then was adequately fed by the remaining riser and no "hot spot" was created. Incidentally, the "yield" of these castings was considerably increased by eliminating this waste of metal.

Publications Received

Ferrous Castings for the Engineer. Published by the British Steelfounders' Association, 304, Glossop Road, Sheffield, 10.

Couched in the most judicious language, this brochure first tells the designer that for shaped components he can use a forging, a drop forging or a casting. Then each sort of ferrous casting is dealt with in turn:—grey iron; high-duty iron; die castings in iron; malleable and steel castings. The die-casting-in-iron section has been emphasised by the use of an italicised paragraph. The section on steel casting receives the same careful treatment, and the use of welding to make composite components is also stressed by italics. Each grade of steel casting is separately dealt with, finishing with the place of centrifugally-cast steels in the hierarchy of castings production. This treatment stresses obvious honesty of purpose and as such will be greatly appreciated by designers. It represents a real swing of the pendulum away from the blatant lying of the market-place huckster—a phase of salesmanship of which the whole world is heartily sick. Thus it is felt that this pamphlet will receive the enthusiastic approbation of the engineering designer.

F.P.A. Journal No. 8, January, 1950. Published by the Fire Protection Association, 84, Queen Victoria Street, London, E.C.4.

Just as there is a fascination in watching a large fire, so to there is real interest in reading about them. This issue stresses the danger of long party frocks and its elimination if the material be Nylon. California now makes it illegal to market any fabric that burns faster than 5 in. in six seconds.

Personal

MR. GRAEME K. HOWARD has joined the board of the Ford Motor Company, Limited.

MR. JAMES RITCHIE has been appointed general manager of the Ailsa Shipbuilding Company, Limited, Ayr.

MR. F. YEO-THOMAS has been appointed the new representative in Paris for the Federation of British Industries.

SIR FREDERICK BAIN, deputy chairman of Imperial Chemical Industries, Limited, left in the Queen Mary on February 7 for a tour of the company's North American interests.

MR. WILLIAM BROWN, a joint managing director of the Chesterfield Tube Company, Limited, has been appointed a Justice of the Peace for the borough of Chesterfield.

MR. J. R. G. BRADFIELD, of Trinity College, Cambridge, has been appointed assistant in research in electron microscopy at the College for three years as from October 1 last.

MR. H. A. A. WHILE, M.B.E., M.A., has been appointed London manager of the United Steel Companies, Limited. Mr. While will remain in charge of the railways department.

MR. GEORGE IVOR RUSHTON, general works manager, and DR. BRYNMOR JONES, head of the research department, have been appointed to the board of the Whitehead Iron & Steel Company, Limited, Newport (Mon).

MR. F. W. SMITH, chief engineer of the Sheepbridge Company, Limited, Chesterfield, is retiring at the end of March after 19 years with the company. He will be succeeded by MR. ERNEST MARVILL, a former works engineer at the Coventry works of the Nuffield Organisation.

MR. STANLEY ERNEST BELL, MR. FREDERICK PEARCE, and MR. FRANK SIMPSON, employees of the South Durham Steel & Iron Company, Limited, who rescued a smelter who had fallen into a narrow space between moulds of molten metal, have been awarded the George Medal.

SIR HARRY RAILING, chairman and joint managing director of the General Electric Company, Limited, sailed on the Pretoria Castle on February 2 for an extensive tour of South Africa, during which he will visit the head office and branches of the British General Electric Company, Limited, at Johannesburg, Capetown, Port Elizabeth, Durban, Salisbury and Bulawayo.

Richard Hill & Company

The Minister of Supply has refused to grant permission to Richard Hill & Company, Limited, to separate their steelmaking interests. In a letter to shareholders and all M.P.'s, Mr. Herbert E. Hill, the chairman, has pointed out that while the business consisted of converting steel billets into rods for wire-drawing and making steel wire and wire products, less than 15 per cent. of the profits were derived from any of the activities specified in the Second Schedule of the Act. The rolling of billets into rods, the only operation falling in this class, he said, is partitively distinct and carried on at a separate works.

As separation is now denied to the company, the step has been taken of forming a new private company called Hill Wire, with a nominal capital of £100, "to carry on the business of drawers in rod, wire, wire rope, cables, and transmission lines and products manufactured therefrom, etc." These activities are not scheduled for nationalisation. If the Act becomes effective, Mr. Hill proposes to continue in business and maintains that present customers have assured him of their support.

Engineering Research

A work-measurement research unit has been established within the Department of Engineering Production at Birmingham University. The main objectives of the unit, which is conducting full-time research work, are:—

(*a*) To investigate, with the co-operation of industrial firms and production engineers, the existing standards of consistency and accuracy obtaining in time-study rating practice among individual engineers, firms, and industries, and to determine the allowances required as compensation for fatigue and other factors in different occupations and under different working conditions.

(*b*) To establish methods of work measurement which will enable the work content of industrial operations to be determined on a more precise basis than hitherto. These methods, which will incorporate the use of reference data, will enable individuals first to be trained to a standard level of consistency and accuracy in work measurement, and, secondly, to maintain this standard by continual reference to these data.

(*c*) To define, on an acceptable reference basis, a "standard work unit," which can be applied to measure and compare the output and productivity of individuals, firms, and industries. This will constitute a reliable basis for international comparison of industrial productivity.

The research unit is also co-operating with the joint committee on the measurement of productivity of the Institution of Production Engineers and the Institute of Cost and Works Accountants. Thus, when the second stage of the project is reached, a wide and representative range of industrial firms can be invited to participate in the development and use of reference standards through these channels. The research work will be placed on a national basis.

Treatment of Pickling Effluent

The method, for neutralisation of steel pickling effluents with limestone grit, in which waste waters are allowed to flow through a tank packed with lumps of limestone, is of little value since the limestone quickly becomes coated with reaction products, especially calcium sulphate when sulphuric acid is present, and thereafter no neutralisation takes place. An improved method provides for acid waste-water to pass upwards through a bed of graded small particles of limestone at a high rate, so that the particles are kept in constant motion and do not remain in permanent contact with one another. The action is similar to that which occurs in backwashing a sand filter. Under these conditions it has been shown that solutions containing up to 5,000 parts of sulphuric acid per million (that is, much more than is required to produce a solution of calcium sulphate in equilibrium with the solid dihydrate) could be continuously neutralised without causing inactivation of the limestone. This information on the treatment of effluents from steel pickling is dealt with in a section of the "Report of the Water Pollution Research Board" for the year 1948, published by H.M. Stationery Office (1s. 3d.).

THE UNIVERSITY OF SAARBRUECKEN has recently taken over the former Kaiser Wilhelm Institute for Metal Research in Tettnang, on Lake Constance. The Institute, which was formerly engaged mainly on aircraft-construction work, is henceforth to concentrate on the improvement of metals in connection with the Saar office for the examination of materials. Later on, this Institute, together with the department of coal chemistry of Saarbruecken University, is to form the nucleus for a college of mining and metallurgy.

The "Lost-wax" Process of Precision Casting*

By J. S. Turnbull

This account deals briefly with the historical aspects of the process and thereafter considers in turn the sequence of operations, die and pattern making, investment and casting. In the concluding paragraphs, the properties of castings and the economies of production are related to present-day market potential; a review is thus given of trends and features which appeal to the engineer-buyer. The Author has been in charge of the precision-casting shop of Metropolitan-Vickers Electrical Company, Limited, ever since its inception in the early part of the 1939-45 war.

Historical

ALTHOUGH the "lost-wax" process of precision casting has been introduced into industry comparatively recently, it was first practised at least four thousand years ago by the ancient Egyptians, and later the Chinese in the Shang dynasty adopted it for making jewellery and objects of art. In the sixteenth century it was rediscovered by Benvenuto Cellini, who used it for casting bronze, silver, and gold.

Before the 1939-45 war, the process was used in the manufacture of jewellery, surgical appliances, surgical instruments, statues, and dentistry.

Application to Dentistry

The dentist could not solve the problem of fitting a gold tooth on to the stub of a broken one by methods which were prevalent in engineering, since it was not possible to make a drawing of the gold tooth and have it made in the machine shop. In order to supply his needs the dentist recreated the "lost-wax" process.

A copper band is fitted around the broken tooth in the patient's mouth (see Fig. 1*a*) and preheated wax is pressed into the cavity so formed and held under pressure until it has solidified. The copper band is slit and removed; the sides of the wax tooth are carved to resemble the shape of the original tooth, and a steel sprue is waxed on to the top of the wax tooth, as shown in Fig. 1*b*. The wax tooth is drawn away from the stub and mounted upside down on the conical crucible former; the sprue is lightly coated with wax (see Fig. 1*c*) and the wax tooth is coated with a fine investment in stages to a depth of $\frac{1}{4}$ in. (The term investment refers to the solids and liquids which are used in making a mould.)

The investment container is waxed on to the bottom of the conical former, and the wax tooth is invested (Fig. 1*e*); the conical former and the sprue pin are heated up and withdrawn (Fig. 1*f*), and the investment air-dried for twenty-four to forty-eight hours before casting.

The investment is heated to 650 deg. C. and maintained at this temperature for two hours to remove all traces of the wax, which first carbonises and then volatilises with the formation of carbon monoxide and dioxide. The gold is melted in the mould, the surface tension of the metal preventing any leakage down the sprue gate (Fig. 1*g*), and when the desired temperature has been reached the mould is pressure cast by direct air pressure, as shown in Fig. 1*h*, or alternatively, by steam generated by the contact of a wet gasket on to the hot mould. When the metal solidifies, the mould is knocked out, the sprue cut off, and the tooth suitably shaped and cemented on to the broken stub.

The wax impression, which is taken in the patient's mouth at a temperature of 35 deg. C., is invested at 25 deg. C., and the resultant contraction is of the order of 0.25 per cent. The investment has a setting expansion of 0.30 per cent., and a thermal expansion of 1.20 per cent. when heated to 650 deg. C. Finally, the contraction of the gold in changing from the liquid to the solid state at 35 deg. C. amounts to 1.25 per cent. Thus,

total expansion $= (0.30+1.20)$ per cent. $= 1.50$ per cent.
total contraction $= (0.25+1.25)$ per cent. $= 1.50$ per cent.

so that the mating face of the gold tooth is an exact fit on the face of the broken stub.

Austenal Process

In America, during the 1939-45 war, small rotor blades for a turbo-supercharger were cast in vitallium to an accuracy of ± 0.0005, and an excellent surface finish was obtained. The process was fundamentally the same as that used in dentistry, although certain modifications were introduced: the wax patterns were made in a split die box instead of carved by hand, and the Austenal moulds were made of high-grade refractories bonded by ethyl silicate.

Towards the end of the war the Austenal process was introduced into this country to provide a method of manufacturing gas-turbine blades. At the present time, the "lost-wax" foundries in this country are still mainly concerned with blade manufacture, although there are a few firms who are casting small miscellaneous components, such as sewing-machine parts.

Lost-wax Process in Industry

The modern application is a modified version of the original Austenal process; it is used either for the mass production of components such as gas-turbine blades, or the production of single components such as the casting of a bakelite die.

Fig. 2 illustrates the sequence of events in the process: the master pattern is first made in either hard wood or metal from the design drawing, which is given an allowance for contraction. The soft metal die is related to the master pattern by precision-casting technique, and the wax patterns are produced from it on injection machines. Finally, these patterns are invested in refractory moulds, the wax is melted out, the mould baked, and the metal component is cast.

Pattern Dies

The accuracy, finish, and speed of manufacture of dies for the wax pattern are of great economic import-

*A Paper read before the Institution of Mechanical Engineers.

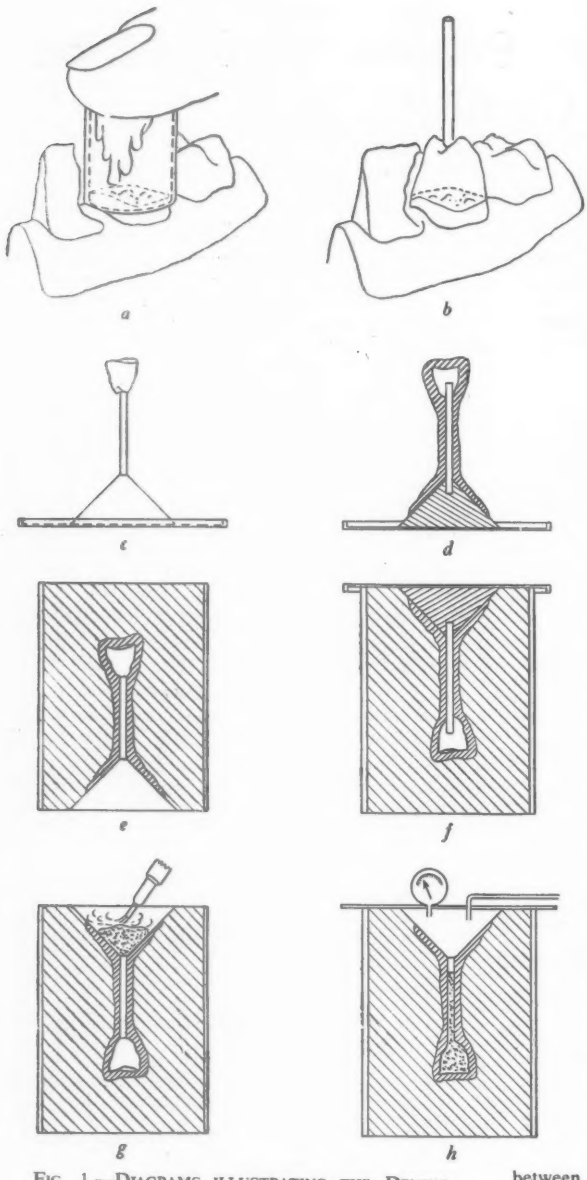


FIG. 1.—DIAGRAMS ILLUSTRATING THE DENTAL LOST-WAX PROCESS.

ance: it is possible to launch a new project in four weeks, allowing three weeks for the die manufacture and one week for the first off-casting. This speed of tool making can only be achieved by making the master pattern in wood and relating its shape to a low melting-point bismuth-tin alloy die by a casting process; the time taken to produce a metal pattern is considerably longer. All wax pattern dies are not made of metal: where accuracy is relatively unimportant the dies may be made of other materials, such as wood, rubber, or ethyl cellulose.

Waxes

The fusible patterns may be made of any material which is stable, fairly strong and easy to handle at room temperatures and which, when subjected to a temperature of 1,000 deg. C. will disappear, leaving the minimum amount of ash. Waxes are the most common materials that meet these requirements. Polystyrene, a plastic stronger than wax and having a melting point higher than most waxes, has been used to a great extent in America. Injection dies make from suitable steels are operated by plastic-type injection machines.

Wax Patterns

The various methods of manufacture of the wax pattern are dependent on the working faces of the pattern. For a pattern in which the working face is the bottom, as in the label former shown in Fig. 3, where the top and and side surfaces of the casting may be machined, the wax is poured into a moulding box located on a master die plate and subjected to pressure to obtain the definition.

For a pattern in which the four sides are the working faces, for example the punch for a bakelite die, the molten wax is poured into a bismuth-tin die box (Fig. 4) and pressure applied to the definition. In the case where both the bottom, top, and the four sides are working surfaces, such as in the switchgear trip-lever shown in Fig. 5, the molten wax is injected into a bismuth-tin die box whose parting line is designed to permit the withdrawal of the pattern. The majority of wax injection dies are of this type; some more complex examples are shown in Fig. 6.

Fig. 7 shows a wax-injection machine operated by an hydraulic ram, on which both the rate of flow of wax entering the die and the ultimate wax pressure can be adjusted. The die is first coated with a parting medium such as tallow or ethyl silicate; it is then closed, the two halves being located by conical locating pins and clamped into the machine. A syringe, preheated to the same temperature as the wax, is filled with wax and placed in the machine, and the hydraulic ram injects the wax into the die. When the wax has set, the syringe is removed, the die is unclamped, and the wax patterns are removed. Fig. 7 shows the finished product, a cluster of thirteen taper strips standing between the two halves of the die; a duplicate die is clamped into the machine. The cycle time for small wax patterns is 3 min.; for larger patterns the time is 5 min.

After the wax models have been inspected, they are built onto wax runners, which are usually made by pouring molten wax into plaster moulds. The assembly work is done in a wooden jig, using hot plates and dental spatulas to join the sub-assemblies (Fig. 8).

The number of wax patterns in one "set up" depends upon the size of the mould box, the metal capacity of

the furnace for casting the finished product, and the efficiency of the "set up" with a view to obtaining progressive solidification. The capacity of the 12-kva. arc furnace (Fig. 15) is about 80 oz. of steel, and, as the weight conversion factor from wax to steel is 7, 11½ oz. is the maximum weight for a wax pattern "set up." Progressive solidification is very essential, the design of suitable ingates and feeding mechanism being of the greatest importance.

Effective facing is ensured by either spraying or dipping the wax pattern; this process also removes any air trapped on the surface of the pattern. The exact procedure, that is whether the pattern is sprayed, dip coated, or invested with a fine mixture of refractory, is almost entirely dependent upon the type of finish required on the casting.

Spraying is done with a standard compressed-air gun (Fig. 9), and the spray is usually a combination of a high refractory and a binder. Potter's flint, powdered silica and zirconium silicate are some of the most common refractories; sodium silicate and ethyl silicate are often used as binders. In normal practice the spray coating is about 0.004 in. thick.

Dipping is done in a suitable container filled with refractory particles and a binder liquid mixed to a creamy consistency; the wax pattern is immersed in the dip for one minute, the pattern being kept in motion continually to allow the complete removal of air from the working faces, drained in a suitable container, and finally stuccoed with silica sand to prevent quick drying and cracking of the dip coating. The sand also has a secondary purpose, in that it will key onto the mould which is subsequently placed around it.

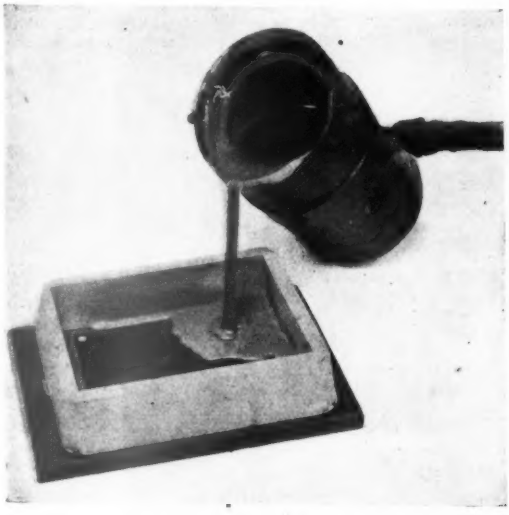


FIG. 3.—MANUFACTURE OF THE WAX PATTERN FOR A LABEL CAST-TO-FORM DIE.

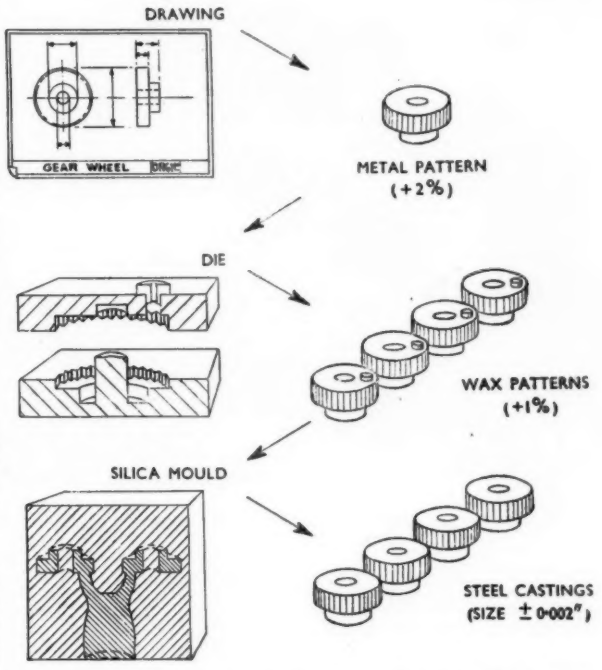


FIG. 2.—STAGES IN THE LOST-WAX PROCESS FOR STEEL CASTINGS.

The Mould Box.—The mould box is a container into which the mould slurry is poured; the base and extension are made of ¼-in. sheet steel as they are removed six hours after the mould has set, but as the box itself has to withstand furnace temperatures of 1,832 deg. F., it is of welded construction and made either of ¼-in. black iron or a heat-resistant alloy such as H.R. Crown Max, Inconel or Hastelloy.

The baseplate locates the wax pattern in relation to the mould box (Fig. 10), and provides a water-tight seal. It is important to ensure that it is waxed all over so that it can be removed easily by melting the wax without damaging the mould. The wax runner is filleted where it joins the base to provide a strong radius on the mould gate.

The mould box is waxed to the baseplate, using a brush and hot wax, and the extension is similarly jointed to the top of the mould box. This extension, which is removed from the mould box at the same time as the baseplate, is waxed on the inside surfaces, and is of tapered design to facilitate easy withdrawal.

The Mould.—Moulds made from silica and plaster of Paris are satisfactory for casting gold and silver alloys having a melting point in the region of 900 deg. C., but for steel alloys with melting points between 1,300 and 1,400 deg. C., a more refractory mould is required. Ethyl silicate, used as a liquid binder with silica, alumina, and other high-grade refractories suitably graded in particle size, is suitable; the hydrolysis of ethyl silicate deposits colloidal silica between the mould particles to bind them together according to the reaction,

$$Si(OC_2H_5)_4 + 2H_2O = SiO_2 + 4C_2H_5OH.$$

The speed of the reaction is governed by several factors,

FIG. 4.—PREPARING A WAX PATTERN FOR A BAKELITE DIE.

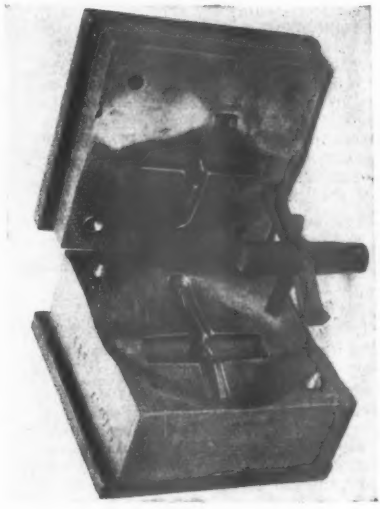


FIG. 5.—A SWITCHGEAR TRIP-LEVER DIE.

including the time, temperature, the electrolyte and the catalyst that may be present.

In practice, a basic oxide is used as a catalyst, the electrolyte is hydrochloric acid, and the binder liquid is ethyl silicate and water dissolved in methylated spirits.

The mould solids are mixed with the binder liquid to form a slurry which is sufficiently fluid to allow efficient pouring and efficient lubrication particles as they pack around the wax pattern (see Fig. 11). The mould box is vibrated to remove air and to assist in efficient packing. The surplus fluid, together with a number of the finer particles, rises up into the mould-box extension, and when the mould has set the liquid is poured off, and the crumbling mould top scraped away.

After the mould has set for six hours, it is ready to be stripped: a gas torch is applied to the base and extension to melt the wax skin between the metal and the mould, as in Fig. 12, Plate 3, and the base and extension can then be removed.

Moulds are usually dried for one or two days: twenty-four hours is sufficient time for a small 6-in. cube, whereas a larger mould, say 6 by 8 by 10 in., would require at least forty-eight hours. To assist the speed of air-drying the temperature should be between 30 and 40 deg. C.

The wax can be recovered by heating the mould box and its contents in an electric oven (Fig. 13), thermostatically controlled between 105 and 110 deg. C., with a specially shaped oven floor to collect the wax, which

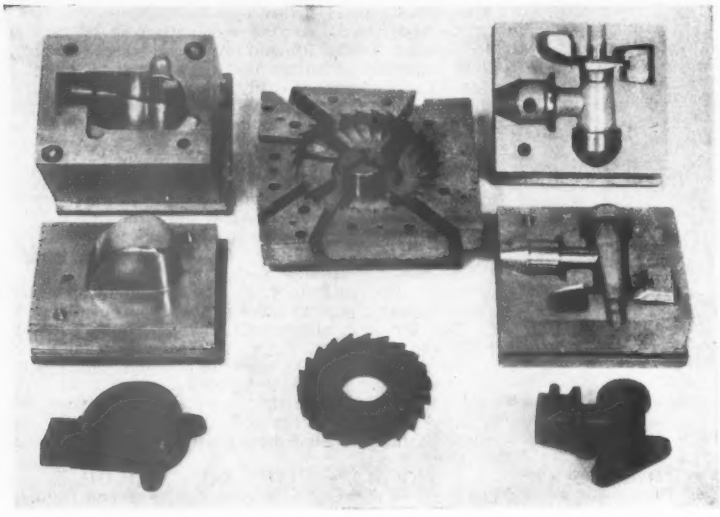


FIG. 6.—COMPLEX WAX-PATTERN DIES AND FINISHED PATTERNS.

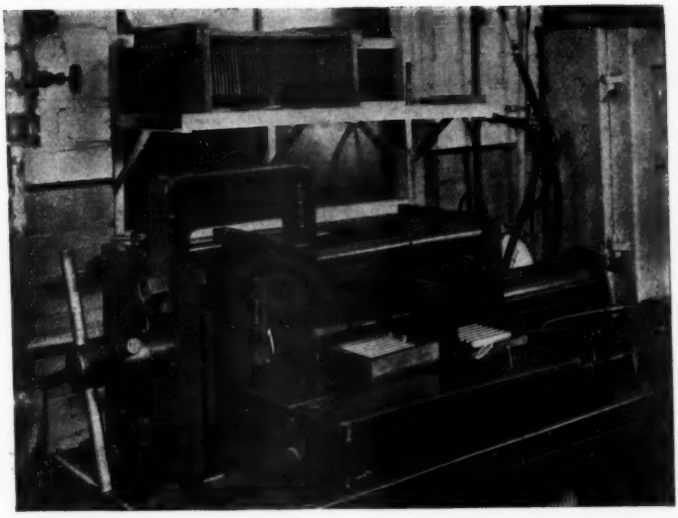


FIG 7.—HYDRAULIC WAX-INJECTION MACHINE.

then flows down a tube provided through the bottom of the oven and is collected in a receptacle placed under the oven. This wax can be filtered and used again.

Only 85 per cent. of the wax is recovered by this process: some will be retained on the mould surface by surface tension and some will soak into the mould. To remove completely all traces of wax from the mould, it is necessary to heat it to a temperature of 1,000 deg. C. for two to four hours, depending on the size of the mould.

The rate of change of temperature in the mould must necessarily be slow as the mould is a poor conductor of heat: otherwise it will crack owing to differential expansion. It is baked in the conveyor furnace shown in Fig. 14, being placed in the cold end at a temperature of 250 deg. C., and gradually heated up to 1,000 deg. C., which is the temperature in the baking zone: a mould 6 by 8 by 10 in. might take five hours to reach a temperature of 1,000 deg. C. The baking atmosphere should be oxidising so that any residual wax will first burn to leave the mould charged with carbon, and subsequently the carbon will burn to form carbon monoxide and carbon dioxide.

The mould after baking will be porous; it is the self-venting properties of a mould which enable so much successful gravity casting to be done in a "lost-wax" foundry. The residual ash from the wax will have little direct effect on the surface condition of the casting, but it will reduce the porosity of the mould.

FIG. 8.—WAX-PATTERN ASSEMBLY BENCH; INDIVIDUAL PATTERNS ARE MOUNTED ONTO A COMMON SPRUE.

FIG. 9.—SPRAYING THE WAX PATTERNS WITH THE FINELY-DIVIDED REFRACTORY CREAM.

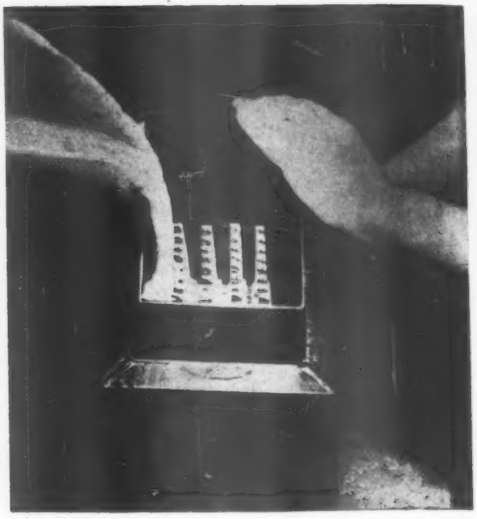


FIG. 11.—INVESTING A WAX-PATTERN ASSEMBLY.

which will cause small dimples in the surface of the casting.

Casting. The 12 kva. indirect furnace shown in Fig. 15 is the simplest form of melting unit; it consists of a metal shell containing a crucible and suitable insulation. The capacity of the furnace is between 2 and 5 lb; the throat diameter is $\frac{1}{4}$ in., and the metal charge is $\frac{3}{8}$ in. diameter bar in 2-in. lengths. The metal temperature can be determined to within ± 10 deg. C. by a platinum-rhodium couple encased in a silica sheath dipped into the molten metal (see Fig. 15). The furnace is designed so that the mould can be clamped to the top face of the furnace with the pouring hole in alignment with the mould gate (Fig. 16). When the mould has been poured, air pressure between 2 and 10 lb. per sq. in. may be applied to force the metal into the mould cavities.

The speed at which the metal enters the mould is controlled by the pouring angle of the furnace and by the speed at which the furnace is tipped. This pouring speed is often very critical since turbulence may occur if the pouring is done too quickly or cold laps may run and the definition be lost if the speed be too slow. The crucible is designed to give the essentials of Durville pouring, the air displaced by the metal being free to rise back into the crucible. When the furnace has been tipped the mould is removed with tongs (Fig. 17).

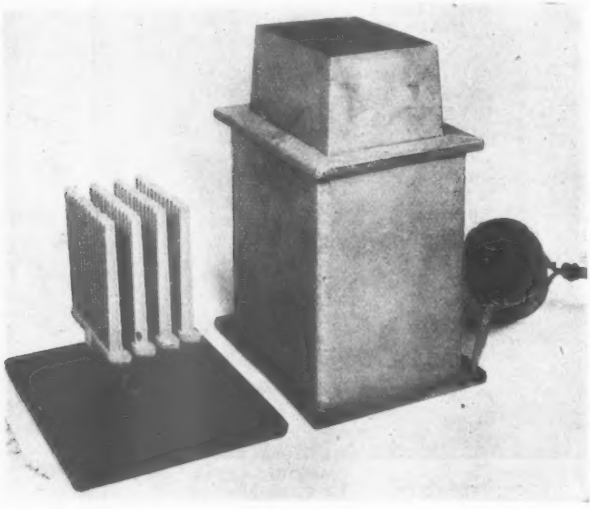


FIG. 10.—ASSEMBLY OF THE WAX-PATTERN UNIT IN THE MOULDING BOX.

FIG. 12.—STRIPPING THE BASE AND EXTENSION FROM THE MOULD.

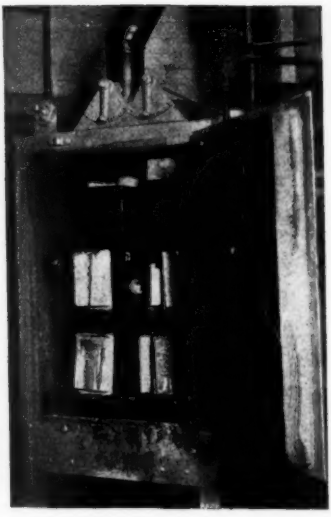


FIG. 13.—DE-WAXING OVEN.

A higher productivity can be obtained with an induction furnace, as the speed of melting is greater. This type of furnace also has additional advantages in that the observation is better, the slag and scum can be raked from the surface before pouring, and any raw material, such as machine-shop bar ends or swarf may be used.

Final Operations. When the mould is cold, the casting is knocked out, shot blasted, cut off on an abrasive saw, fettled, inspected, and, if required, radiographed. Since all castings are processed through an abrasive saw it is essential that the wax set-up is designed so that individual components can be cut off by the saw. For example, if four components are jointed symmetrically around the feeder bar, it may be impossible to find clearance for the saw blade: a design which places three symmetrically and the fourth (say) one inch below the other three would be advantageous. There is no better guide to the production of sound castings than the radiograph. It will show the presence

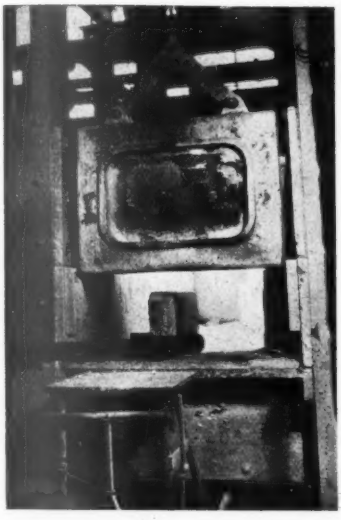


FIG. 14.—FURNACE FOR INVESTMENT BAKING; MOULD PLACED IN THE 1,000 DEG. C. ZONE.

FIG. 15.—12-KVA. ELECTRIC-ARC FURNACES FOR METAL MELTING.

FIG. 16.—CLAMPING A MOULD TO A FURNACE.

FIG. 17.—REMOVING A MOULD FROM A FURNACE AFTER POURING BY INVERSION.

of trapped gases due to imperfect venting, blow holes due to gases dissolved in the molten metal, and porosity resulting from non-progressive solidification.

Properties and Uses of "Lost-wax" Castings

The surface finish obtainable on a "lost-wax" casting is one of its strongest selling points: such a casting can be polished direct without using an emery roughing wheel. The accuracy of the castings can in most cases be held to within ± 0.003; on small components tolerances of ± 0.0005 are possible.

If the set-up is designed for progressive solidification, a high degree of metallurgical soundness is obtainable, but a casting is not as metallurgically sound as a forging. Comparisons made between castings and forgings in a chrome molybdenum steel show that the forging has a tensile strength of 60 tons per sq. in with an elongation of 22 per cent., wheras the casting has a tensile strength of 52 tons per sq. in. with an elongation of 17 per cent. The discrepancy is due to the oxide films and micro-porosity in the cast structure. The metallurgical soundness of the surface of a casting can be checked with either a magnetic or fluorescent crack-detection apparatus.

The "lost-wax" process finds an application in cases where (*a*) the metal is unmachinable, such as in Stellite taper strips and knife edge bearings (Fig. 18); (*b*) the shapes of the components are unmachinable, such as the tee piece with a curved hole shown in Fig. 19; (*c*) production by other methods is uneco-

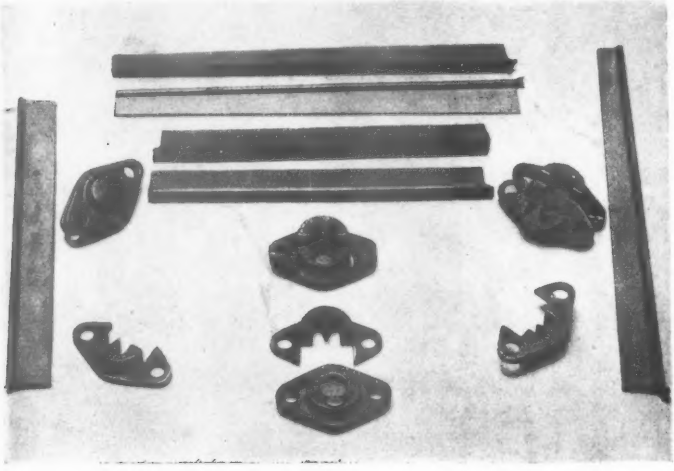


FIG. 18.—PRECISION-CAST TAPER STRIPS AND KNIFE-EDGE BEARINGS IN STELLITE.

FIG. 19.—TEE-PIECE CASTING WITH CURVED HOLE IN H.R. CROWN MAX MATERIAL.

(*a*) (*b*)

FIG. 20.—CONSIDERATION OF SHAPE IN RELATION TO MANUFACTURE BY LOST-WAX PROCESS.

(*a*) Suitable for manufacture on machine-shop lathe.

(*b*) Extrusion cone suitable for manufacture by lost-wax process.

nomical (see Fig. 20 *b*); and (*d*) the production of prototypes by other methods takes too long.

The majority of "lost-wax" castings come into category (*c*): they would be expensive to make in the machine shop either because the metal is too hard, as in the case of a Nimonic gas-turbine blade, or else because the job is multi-operational as in the case of the miscellaneous castings shown in Fig. 21.

An example of category (*d*) is the gas-turbine compressor blade shown in Fig. 22*a*. Two methods were available for its manufacture: it could be made either as a pressing in precision-steel dies, or as a "lost-wax" casting; by the first method the time to produce the prototype would be four months, by the "lost-wax" process the time was reduced to six weeks. The fastest completion of any order was the two switchgear keys shown in Fig. 22*b*, which were despatched five days after the order was placed.

Tool Costs.—The total cost in "lost-wax" casting is relatively low compared to the costs involved in alternative methods of manufacture. In a machine shop it may be necessary to design tool fixtures when dealing with a mass-production project; in a precision pressing it will be necessary to manufacture a number of steel dies, but in "lost-wax" casting the die cost is functional with the number of castings required. Recent developments have shown that wax injection dies can

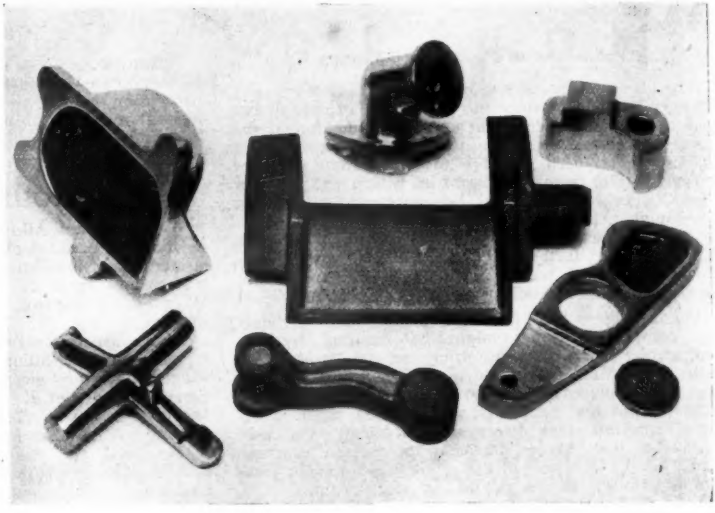


FIG. 21.—GROUP OF PRECISION CASTINGS. IN EACH CASE A MACHINED COMPONENT OF SIMILAR DESIGN WOULD HAVE BEEN MORE EXPENSIVE.

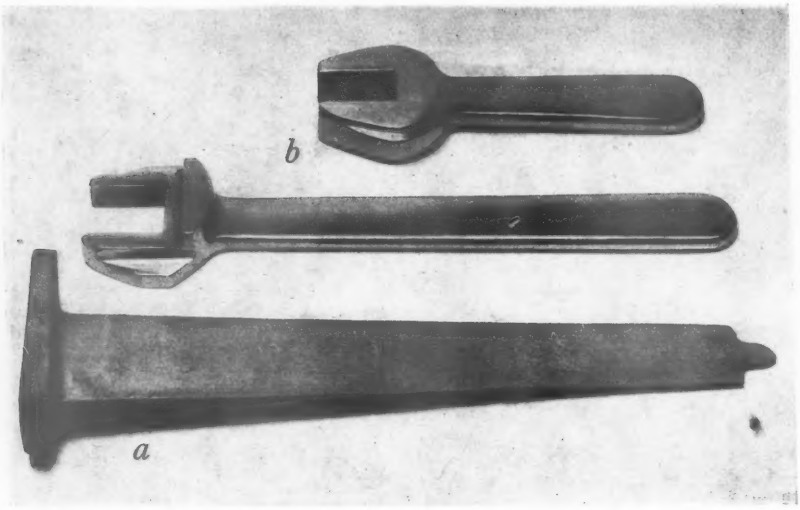


FIG. 22.—LOST-WAX CASTINGS. (*a*) GAS-TURBINE BLADE; (*b*) SWITCHGEAR SPANNERS.

be made in plaster of paris for 20 castings or less. In this case the cost of the die is about £5. For the production of more than 20 castings a bismuth-tin die is required which might cost £50. (The Author has no precise knowledge as to the maximum number of wax models which can be made in one bismuth-tin die, but it is known that 5,000 models have been made, and there is reason to suppose that, if a reasonable amount of care is taken by the operator, this figure might exceed 10,000.)

Among the metals which have been cast successfully by the "lost-wax" process are Nimonic 80, Nimonic 75, the Stellites, H.R. Crown Max, S.80, chrome molybdenum, ½ per cent. molybdenum, F.C.B., aluminium alloys and brass.

Economics of "Lost-wax" Casting

The accurate proccessing of "lost-wax" castings is of primary importance since the production of cheap castings is necessarily dependent upon the reduction of the scrap percentage. On the production of gas-turbine blades it has been possible to mass-produce blades varying in size from 8¼ in. to 4 in. with a scrap of less than 30 per cent.; this has been achieved by process development, largely based on the analysis of defective castings. It seems possible that the scrap percentage can be reduced further, and it would not be unreasonable to expect the scrap on blades to be below 10 per cent. in two years' time.

The casting of blades is more difficult than the average component which might be required by the commercial market because they are not designed as castings, the ratio of volume to surface area is a minimum, they present a combination of thick and thin sections, and the metallurgical soundness required on radiograph and crack detection is very high. On castings other than blades the scrap percentage approximates to 20. The present cost under development conditions amounts to 30s. per lb. for steel castings.

Conclusion

It may be considered that the cost of "lost-wax" casting is high and that the future must necessarily be restricted on this account, but only when the process has become accurately stabilised can there by any effective solution to economical manufacture. This can be effected by process simplification; at present there are 25 different stages in manufacture. The application of mechanisation and motion study, as in any multi-operational process, will have a great effect in reducing the costs. Thus it is not inconceivable that the cost of "lost-wax" castings will have dropped to 10s. per lb. within the next five years.

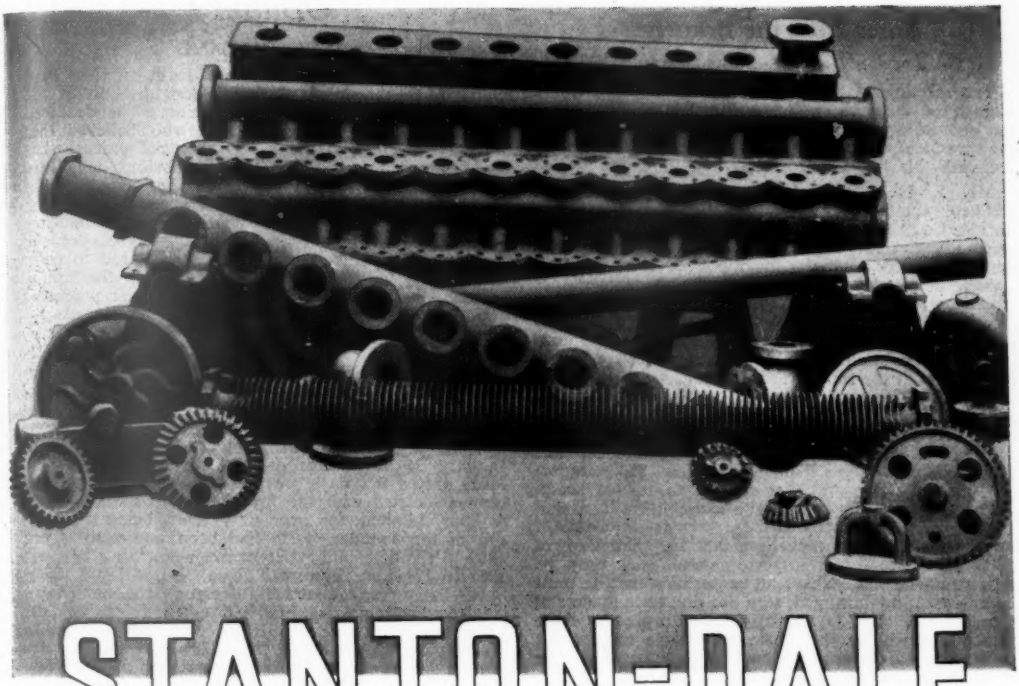
Acknowledgments

Acknowledgments are made to the directors of Metropolitan-Vickers Electrical Company, Limited, for permission to submit this Paper, and to the metallurgical research team at Metropolitan-Vickers for the assistance given to the Author in its preparation.

House Organ

Wiggin Nickel Alloys. The important part played by nickel in ocean depth-sounding equipment is demonstrated in an interesting and fully-illustrated article in the current issue of this booklet issued by Henry Wiggin & Company, Limited, Wiggin Street, Birmingham.

Shorter articles deal with the use of Monel in cannery pipelines, bottle-filling machinery, pumps, rotary vacuum filters and electro-steam equipment. A description of the use of K Monel in reconditioning pumps for high viscosity, corrosive liquids is of particular interest. A new use for Inconel in medical equipment is described and the makers' experience with continuous-annealing furnace tubes in this alloy is briefly outlined.



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The above illustration shows a group of castings made by Messrs. Goodbrand & Co. Ltd., Stalybridge, Cheshire.

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Notes from the Branches

London Branch—Slough Section

The meeting of the Slough Section of the London Branch of the Institute of British Foundrymen, held last month, was the occasion of an official visit by the president, Mr. F. Arnold Wilson, and honorary secretary, Mr. W. G. Mochrie.

Mr. J. Howard Williams, of Holman Brothers, Limited, Camborne, Cornwall, presented a slightly abridged version of his Paper, "Casting Inspection," originally given to the Wales and Monmouth branch, which featured not only the more obvious technical aspects of inspection, but the psychological attributes which are necessary to the make-up of a good inspector. These qualities, which were emphasised with several humorous illustrations serving to show the importance of human relations, had undoubtedly been used to great effect in the foundry. In conjunction with a high degree of technical ability, the concern could reduce foundry scrap to a maximum of 5 per cent., and machining scrap to 1 per cent. on a variety of intricate ferrous and non-ferrous castings, none of which was produced on a larger than batch scale. Mere inspection and rejection was not enough to reduce scrap, unless the inspector sought the cause of failure, and then suggested a remedy to those responsible in such a way as to lead them to believe that they had thought of it themselves. An inspector should not only be observant—he should have an enquiring mind; he must be unbiased; he must stick to a decision once made and repeat it at a later date, and in order to practise these principles fairly he should be responsible only to the management. Under such conditions, the best could be obtained from casting inspection.

The discussion had to be rather curtailed owing to the time, but several points were dealt with. The question of out-of-alignment of moulding boxes was raised and the lecturer suggested the use of small dowels in opposite corners. Here MR. LOGAN pointed out the recent setting up of a sub-committee on the standardisation of moulding boxes, primarily instigated as a result of a meeting of the Slough section some two years ago, and added that this point could be brought to its attention. Deviation of a casting from the pattern-maker's rule was raised, and it was agreed that variable conditions occurring in a particular casting sometimes necessitated making the pattern "wrong according to the rule," to permit satisfactory final dimensions to be obtained.

MR. BLANDY asked what methods of detection were used for gas porosity. In reply, the lecturer stated that slight surface depressions were often a useful means of detection, but where these were absent perhaps only a pin-point hole might be evidence of extensive sub-surface porosity, and it was here that the inspector's experience, perception and far-sightedness could save an expensive machining operation.

Finally, a vote of thanks was proposed by MR. LOGAN, who gave as his opinion, that this Paper could be heard with advantage by other branches of the Institute.

Newcastle-upon-Tyne

The president of the Institute of British Foundrymen, Mr. N. P. Newman, and the general secretary, Mr. T. Makemson, were present at the January meeting of the Newcastle-upon-Tyne branch. During the course of a short address, the president expressed his pleasure in visiting Newcastle and emphasised the importance of

(*Continued at foot of next column.*)

every branch, large or small, in governing the Institute's affairs.

Mr. H. Smith, branch-president, then gave a Paper on "Pattern-making Methods as Applied in the Foundry." Various examples of patterns made without the co-operation of the moulders were shown and it was explained how these patterns could have been modified with a great saving in production time and money by taking advantage of the practical experience of the moulders. A lengthy discussion followed and many points relating to pattern-making methods were put forward. Mr. W. Scott proposed a vote of thanks to Mr. Smith for his practical Paper, which, he felt sure, all members had enjoyed.

Obituary

PAUL BALLAND

We regret to announce the death of M. Paul Balland, the president of the Eastern division of the French foundry employers' federation. The deceased was a gentleman of real charm, who believed that industry was helped along by the social graces. His great knowledge of wines and his obvious delight in acting as host were everywhere appreciated. His enthusiasm for the foundry industry and his real gift for leadership have left a void in French industry which can never be quite filled. Members of the British foundry industry who were privileged to meet M. Balland will associate themselves with the Editor in tendering to their French colleagues their profound condolences on the great loss they have sustained.

S. S. WRIGHTSON

Mr. S. S. Wrightson, a director of Thomas Summerson & Sons, Limited, railway engineers, of Darlington and of their subsidiaries, which include Summerson's Foundries, Limited, of Albert Hill Foundry, Darlington, steel and iron founders, died suddenly on January 31 at the age of 79. He had been at his office only a few days previously. Mr. Wrightson had been associated with the firm of Thomas Summerson & Sons, Limited, for over sixty years, being a grandson of the founder. He had been a director from 1900 to the date of his death; managing director from 1921 to 1941; and chairman from 1941 to 1944.

He had taken an active interest in the company's ironfounding activities, and had taken a leading part in the decision made in 1910 to commence production of steel castings. During the 1920's and early 1930's he was a regular attender at meetings of the then General Steel Castings Association on behalf of his company. His pleasing personality and obvious sincerity were recognised by all who came into contact with him, and the widest sympathy is extended to his two sons who survive him, one of whom, Mr. Stephen Wrightson, is a lecturer at the National Foundry College, Wolverhampton. Mr. Wrightson was a gifted amateur landscape artist, and in his younger days he had been a keen angler.

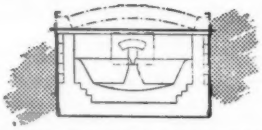
MR. WILLIAM ALLARDES, late of A. & J. Inglis, Limited, shipbuilders and engineers, of Glasgow, died on February 2.

MR. WILLIAM LEIGHTON, founder of William Leighton, scrap-iron merchants, of Wednesbury (Staffs), has died at the age of 71.

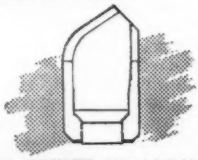
MR. OSWALD GREENWELL, who died recently, was general manager of the ironfoundry division of Head, Wrightson & Company, Limited, Thornaby-on-Tees. He had been with the company 29 years and had planned the new foundry which is being built at Eaglescliffe. He was 64.

BRITAINS BEST BASIC REFRACTORIES

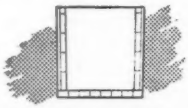
G·R '341' DOLOMITE BRICK



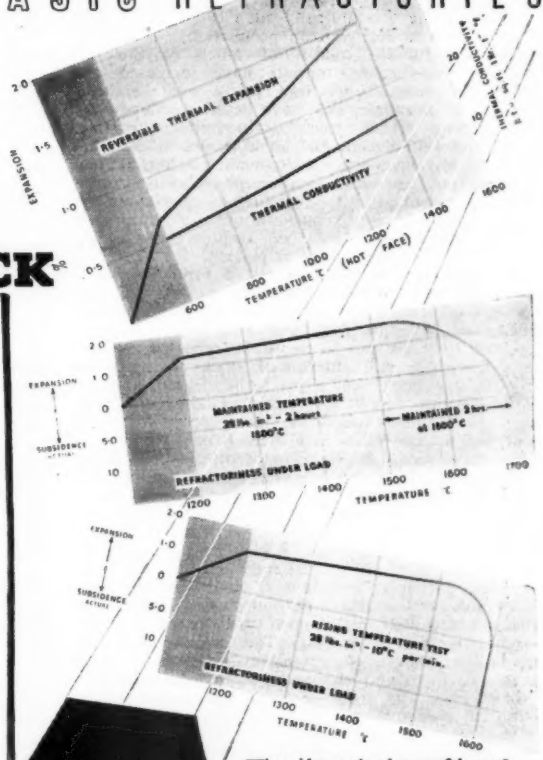
ELECTRIC FURNACES G.R. '341' dolomite bricks are used extensively in walls and bottoms of basic electric arc furnaces. Proved the most economic basic brick available. Complete absence of chromic oxide makes '341' most suited for production of chromium-free alloys. Any size furnace can be lined from standard stock sizes.



BASIC BESSEMER CONVERTER G.R. '341' bricks, dense and burnt to vitrification at high temperatures are superior to rammed tarred dolomite or 'green' tarred blocks in the lower wall positions. In addition to giving much longer and uniform life to the converter the efficiency of the process is greatly improved. Highly resistant to chemical erosion and mechanical attrition.



DESULPHURISING LADLES G.R. '341' bricks provide the perfect lining and solve completely the refractory problems connected with sulphur removal by the sodium-carbonate process. Give a life 8 to 10 times longer than firebrick without patching or attention. A perfect chemical (basic) medium which in addition to longer lining life increases efficiency of process.



The widespread and successful use of the G.R. '341' dolomite brick in Basic Electric Furnaces, Bessemer Converters and Desulphurising Ladles is one of the major achievements in refractories. G.R. '341', the result of many years research and experimentation, is manufactured entirely from British Dolomite and is treated to ensure resistance to atmospheric moisture. Like all G.R. Basic Bricks, '341' is made in one of the most modern plants, embodying all the features of improved brickmaking technique and possessing valuable characteristics developed by years of experience. Full information and advice on the selection and application of refractories will be given on request.

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Raw Material Markets

Iron and Steel

Partly due to the mild winter, blast-furnace men are experiencing less difficulty than usual in securing the raw material for pig-iron production. Moreover, despite the dubious quality of much of the fuel supplied, blast-furnace outputs have increased and supply and demand are now fairly well balanced. Most of the foundries still have healthy order-books. Establishments which specialise in builders' castings are not so well placed, but an extensive market has developed for engineering and special castings. Thus, the output of low- and medium-phosphorus iron is eagerly absorbed, and the production of hematite is passing promptly into consumption. Producers of common foundry iron have no surplus tonnage and refined irons command a good market.

The contraction in the imports of foreign semis is not probably a merely temporary phase. In this respect the British steel industry is aiming at a greater measure of self-sufficiency and the swollen import figures of 1949 are not likely to be repeated. At all events, there are still substantial stocks of imported and home-produced steel semis to be cleared, and the only categories for which the demand keeps pace with, and at times outstrips, the supply are small round and square billets and sheet bars.

Obviously, record-breaking ingot outputs could not be sustained except on the basis of a substantial market for finished steel products, and the experience during the first few weeks of 1950 justifies the forecast that in exports of heavy steel there is still a hopeful field for expansion. Recent heavy steel shipments to Australia, New Zealand, and the Far East have been particularly impressive, and various steelmakers are now engaged on substantial orders for Canada which will be shipped as soon as the St. Lawrence is free for traffic. The demand for ship and boiler plates is extensive and very large tonnages of joists and sections are on order. Makers of small bars and light sections are rather slack, possibly in consequence of keen Belgian competition, but the call for sheets and strip far exceeds the supply, and rail mills are still working to capacity.

Non-ferrous Metals

The volume of buying by consumers shows a tendency to decline, but, nevertheless, a fair amount of business is passing and doubtless the Ministry of Supply is finding that the fabricators are taking pretty good tonnages of copper and zinc. In contrast, trading in tin has been rather brisk, although the weekly turnover still compares badly with pre-war days. So far as the price is concerned, practically no change has occurred in the cash position, but the three months' quotation has slightly improved, and thus the backwardation has been reduced to approximately £14—the lowest figure recorded since trading began in November last. It is not unlikely that in the near future the backwardation will be eliminated, and it may be hoped that thereafter the market will assume a more normal appearance, with the return of a contango which will facilitate hedging operations.

Metal Exchange tin quotations were as follow:—

Cash—Thursday, £599 10s. to £600; Friday, £599 15s. to £600; Monday, £599 15s. to £600; Tuesday, £599 15s. to £600; Wednesday, £599 10s. to £600.

Three Months—Thursday, £584 to £584 5s.; Friday, £584 10s. to £584 15s.; Monday, £586 to £586 10s.; Tuesday, £586 15s. to £587; Wednesday, £585 15s. to £586.

Conditions in the scrap market are pretty well unchanged, although last week there was not quite as much activity as during January. Prices remain constant, but the tone is firm and certain types of scrap, among which may be mentioned brass swarf, have shown a tendency to harden somewhat. One of the chief complaints heard from consumers is that material is scarce and this seems rather strange in view of the recent announcement that the Government intended to sell some 40,000 tons of non-ferrous scrap in one lot.

It would not appear that a decision has yet been reached in regard to this matter, but in some quarters it is believed that the plan will be abandoned in favour of monthly sales by tender. In that case the present rate of offering will need to be increased. The more rapidly the disposal system can be made to function, the quicker will the authorities achieve their object of reducing stocks.

Blowing Engines Dismantled

G. & R. Thomas, Limited, Hatherton Furnaces, Bloxwich (Staffs), has recently completed the dismantling of its two old blowing engines, one of which dated back to some time prior to 1844. The oldest engine had two steam cylinders, each 28-in. dia., which operated two blowing cylinders measuring 48-in. dia. respectively. The flywheel was 15-ft. dia. and the two beams, which were of cast iron, weighed approximately 5 tons each. The spear rods were of oak. It is not known who the makers of this engine were and there is nothing in the company's records referring to it. The engine was in working condition up to 1940 and was used when the larger engine was being overhauled.

The larger engine was a single-cylinder beam engine operating a single blowing cylinder. The steam cylinder was 39-in. dia. and the blowing cylinder 100-in. dia. The cast-iron beam weighed 20 tons and the flywheel, which was 25-ft. dia., weighed nearly 40 tons. On this engine the spear rod was of pitch pine. The engine was built by the Lilleshall Engineering Company, of Shifnal (Salop), and was originally erected in Derbyshire, but was dismantled and re-erected at Bloxwich in about 1880. It blew the blast furnaces regularly up to 1943, when its work finally finished on the installation of steam-driven turbo-blowers. It is interesting to note that both these engines were bedded on to large sandstone blocks.

Foundry Pig-iron

An important query was raised in the speeches following the annual dinner of the Birmingham, Coventry and West Midlands branch of the Institute of British Foundrymen, held at the Botanical Gardens, Edgbaston, Birmingham, and presided over by Mr. H. G. Hall. Mr. C. R. Wheeler, a director of Guest Keen & Baldwins, Limited, was the principal guest. He drew attention to the magnificent production of the iron and steel trades, and stressed that the ironfoundry industry had done still better. Between 1946 and 1949, steel output had increased by 23.5 per cent., while iron castings had expanded by 32.6 per cent.

Mr. Hall took up this question of focusing public attention on steel-output records, and pointed out that under nationalisation, with its planned need for steel-making pig-iron, the special requirements for pig-iron by the foundry industry may be neglected.